



TOUGHTray

- Instructions -
(TSS Support Reccomendations)

TT-I-02_A01



TOUGHTray Longer Span Optimization

(Horizontal Cable Tray Run)

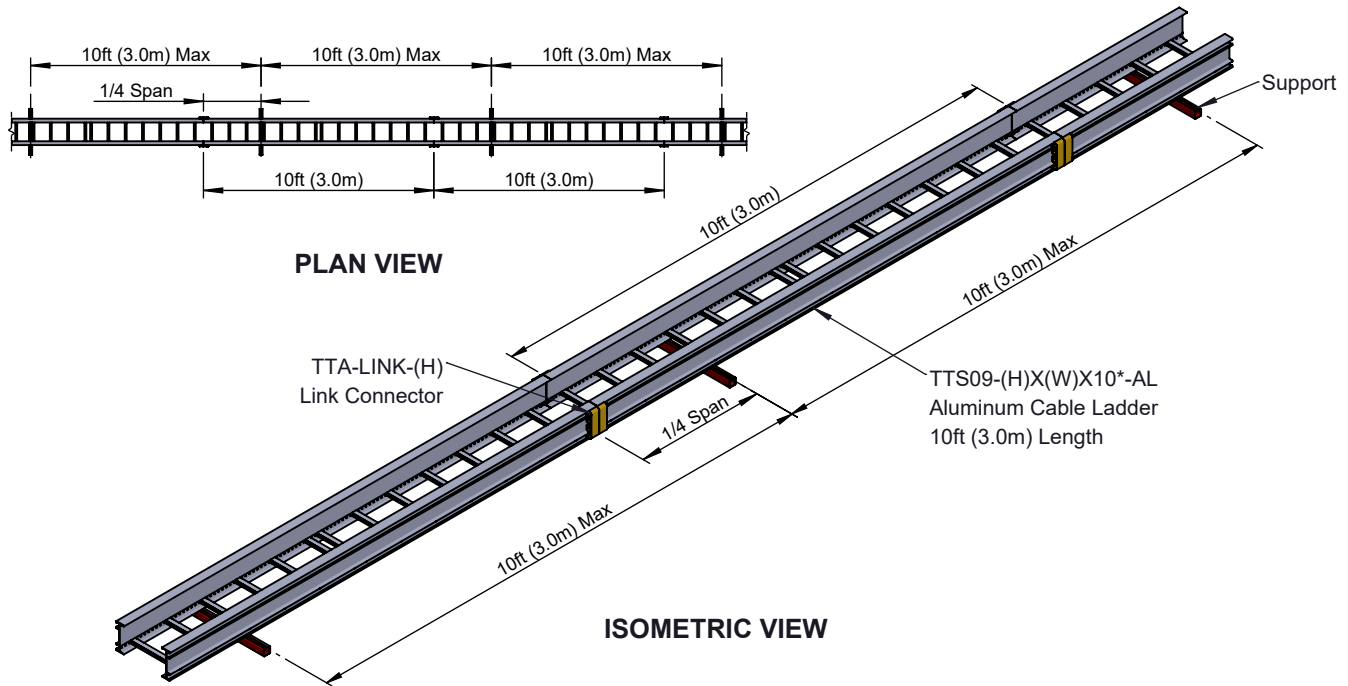


FIGURE 1: NEMA 10* (NOT OPTIMIZED)

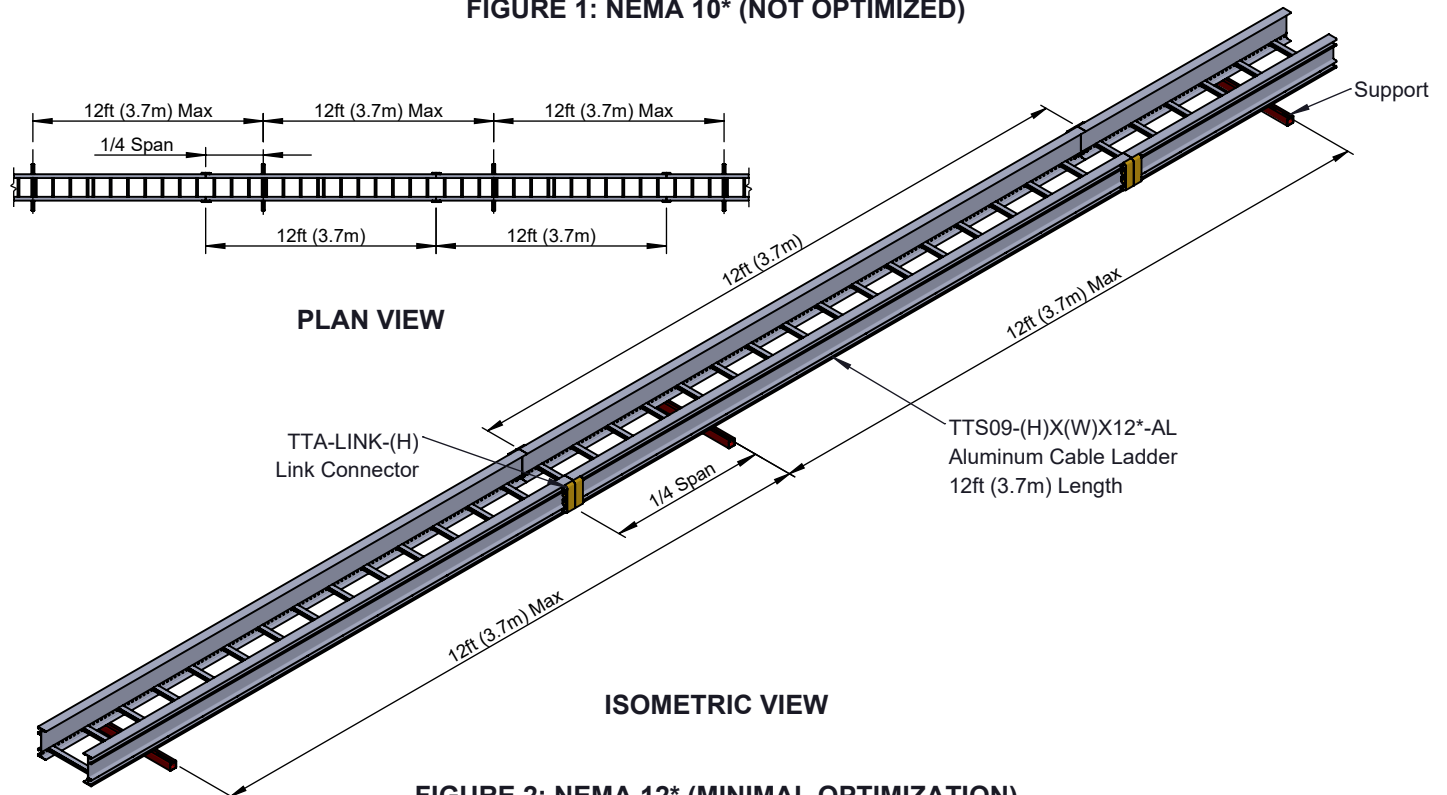


FIGURE 2: NEMA 12* (MINIMAL OPTIMIZATION)



TOUGHTray Longer Span Optimization

(Horizontal Cable Tray Run)

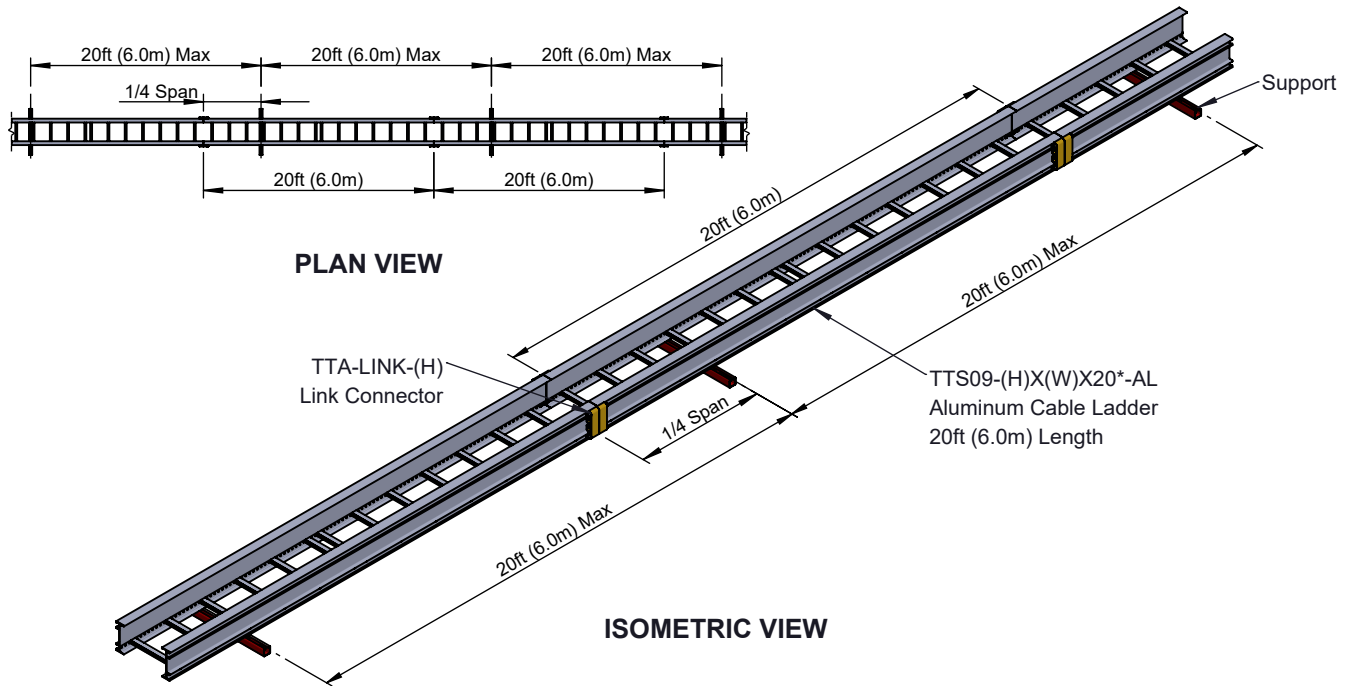


FIGURE 3: NEMA 20* - QUARTER SPAN (MAXIMUM OPTIMIZATION)

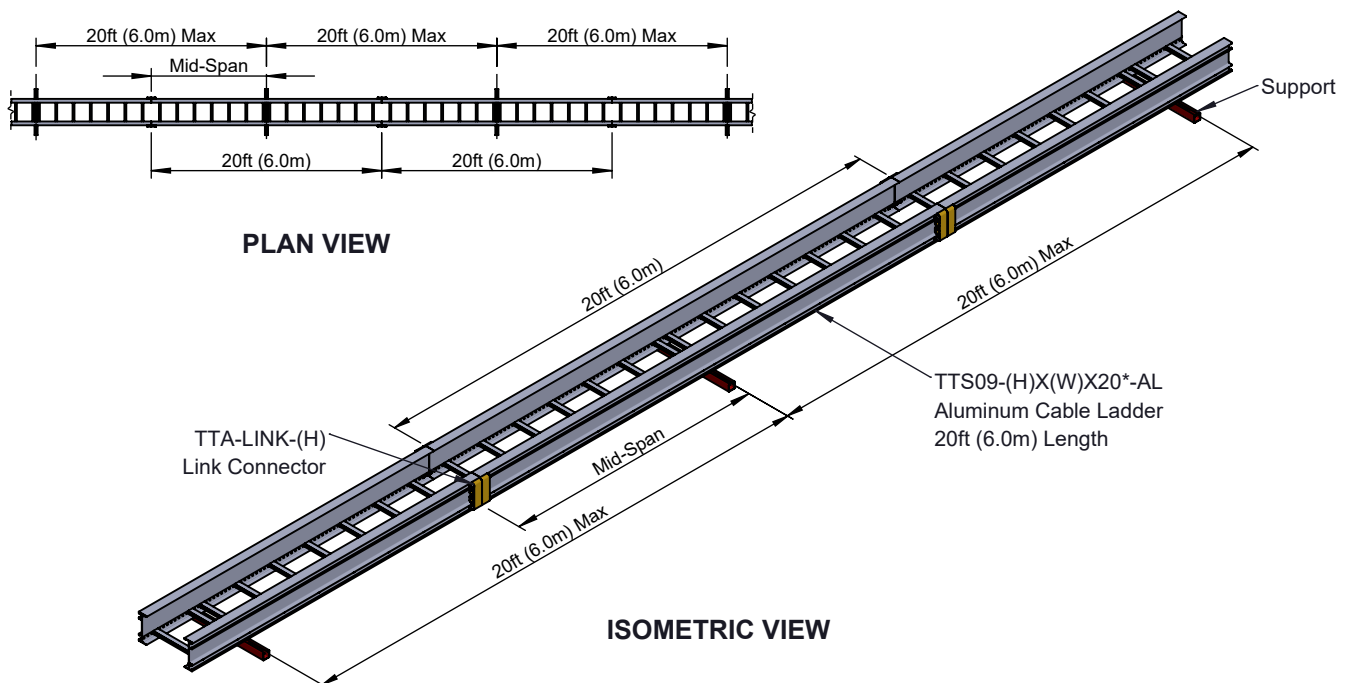


FIGURE 4: NEMA 20* - MID-SPAN (MAXIMUM OPTIMIZATION)



TOUGHTray Longer Span Optimization (Vertical Cable Tray Run)

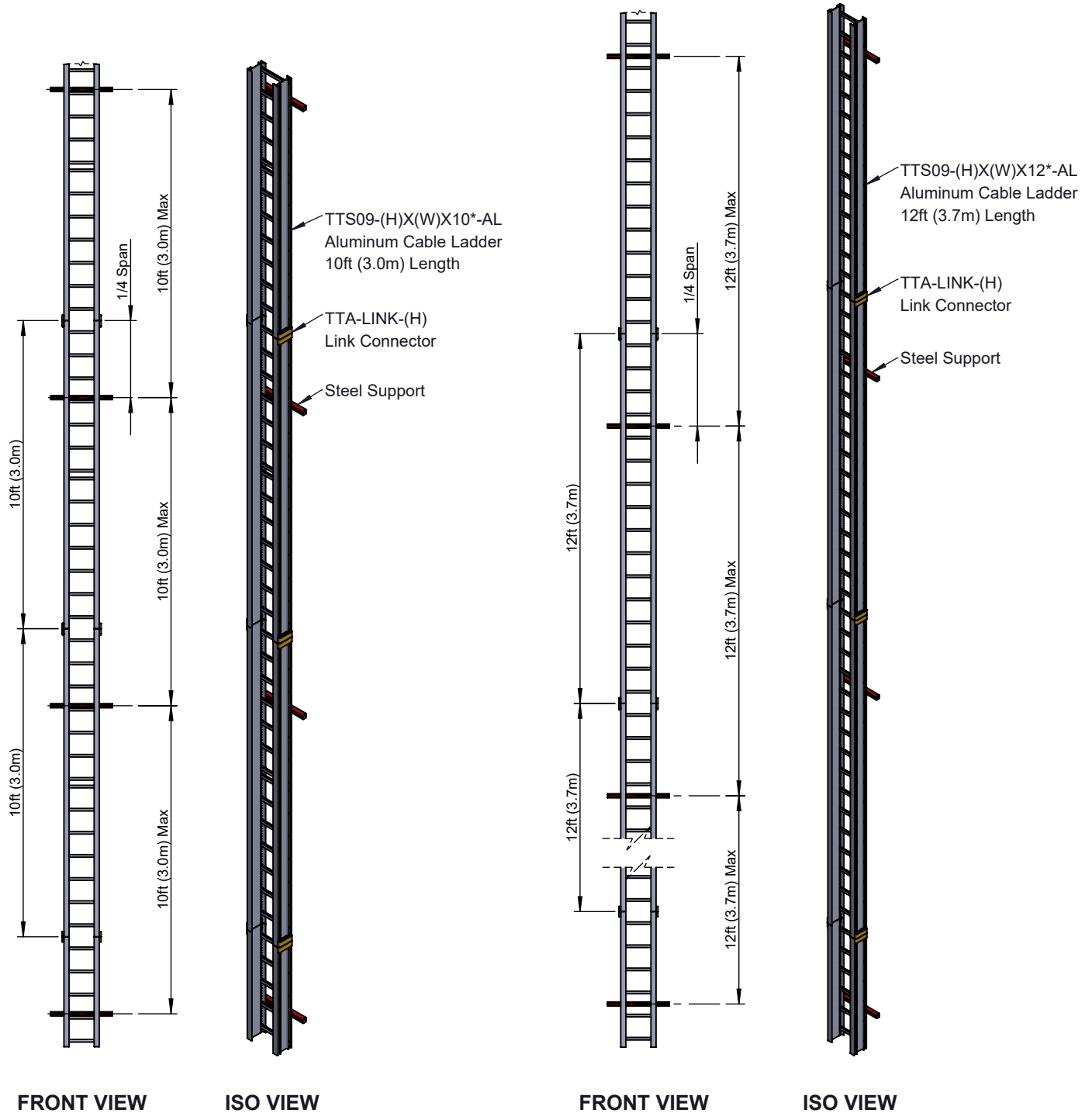


FIGURE 1: NEMA 10*
(NOT OPTIMIZED)

FIGURE 2: NEMA 12*
(MINIMAL OPTIMIZATION)



TOUGHTray Longer Span Optimization (Vertical Cable Tray Run)

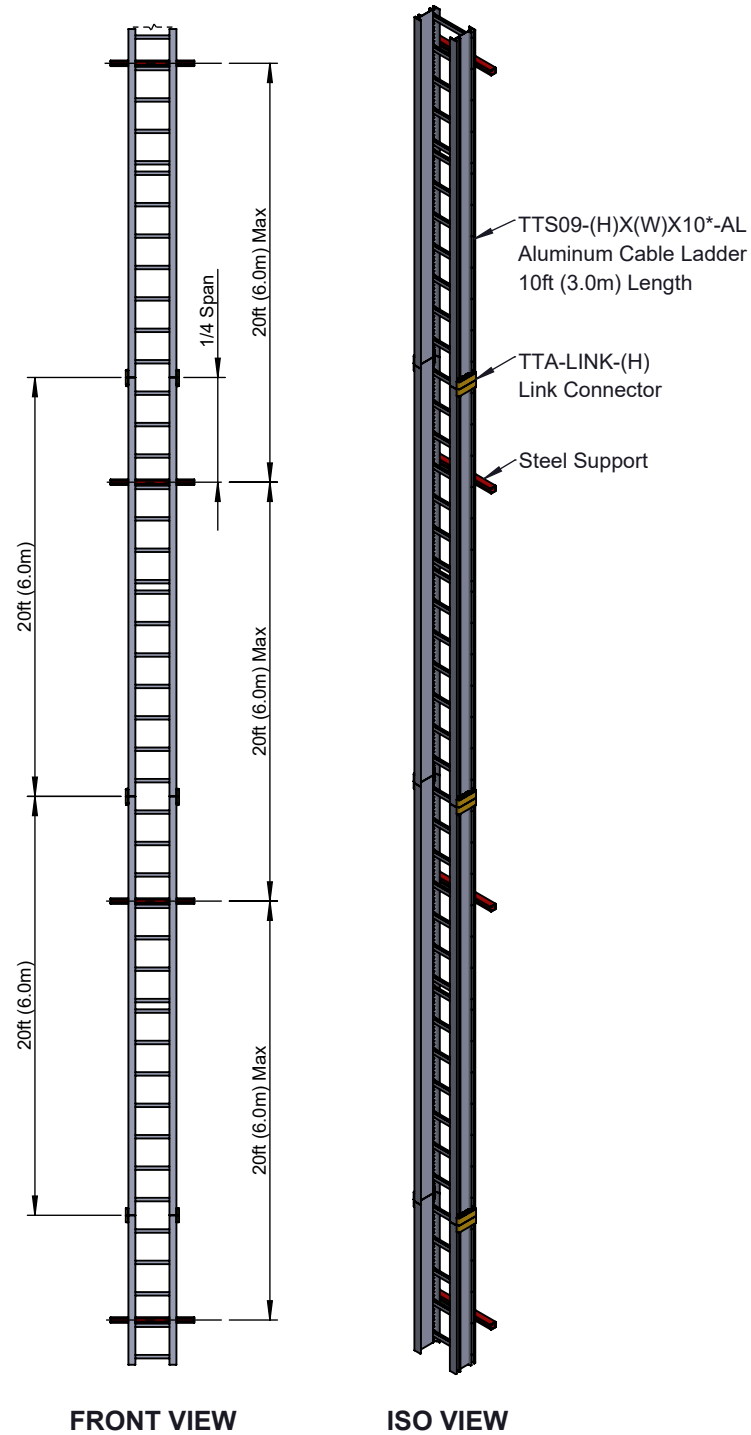
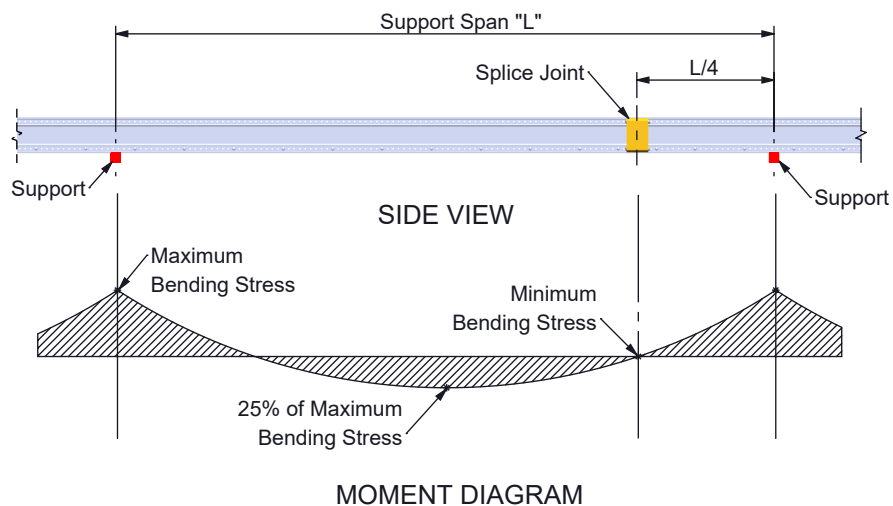
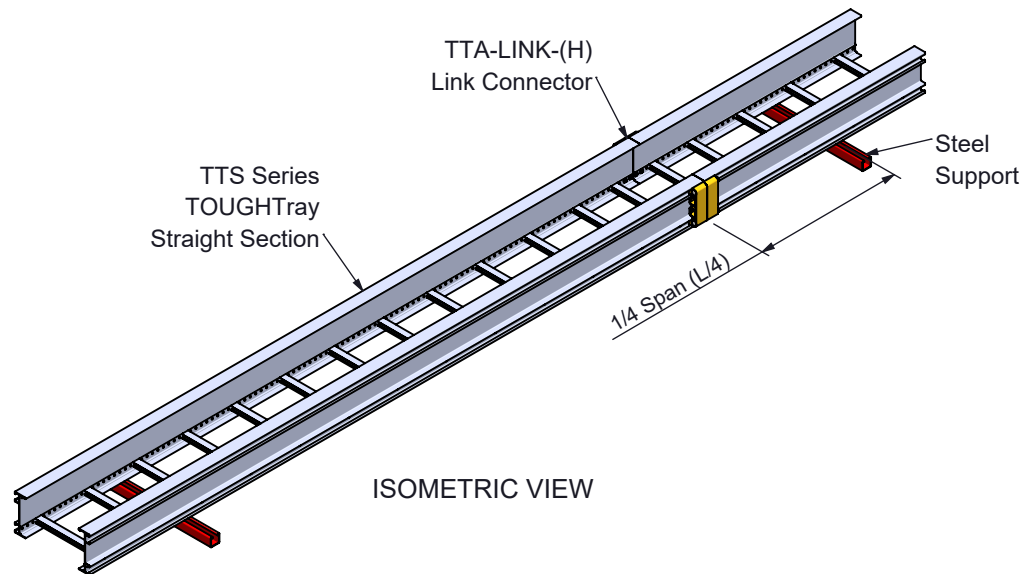


FIGURE 3: NEMA 20* (MAXIMUM OPTIMIZATION)



TOUGHTray Connecting LINKs Location



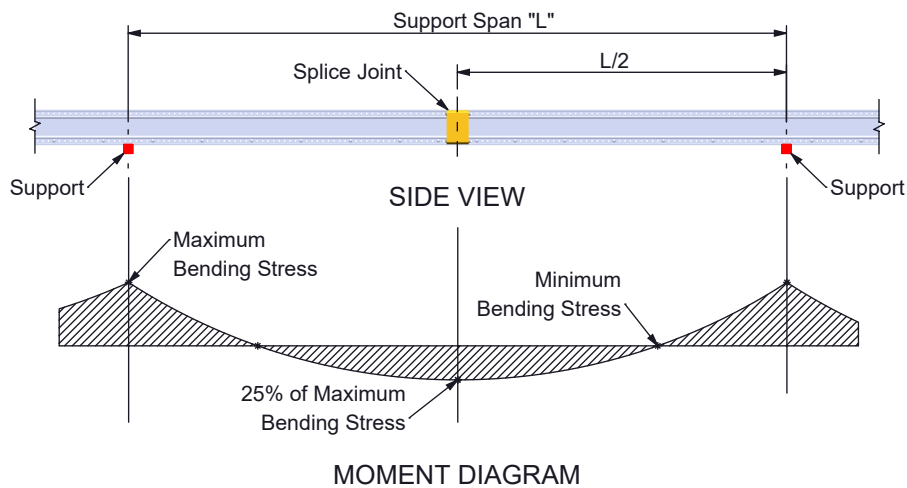
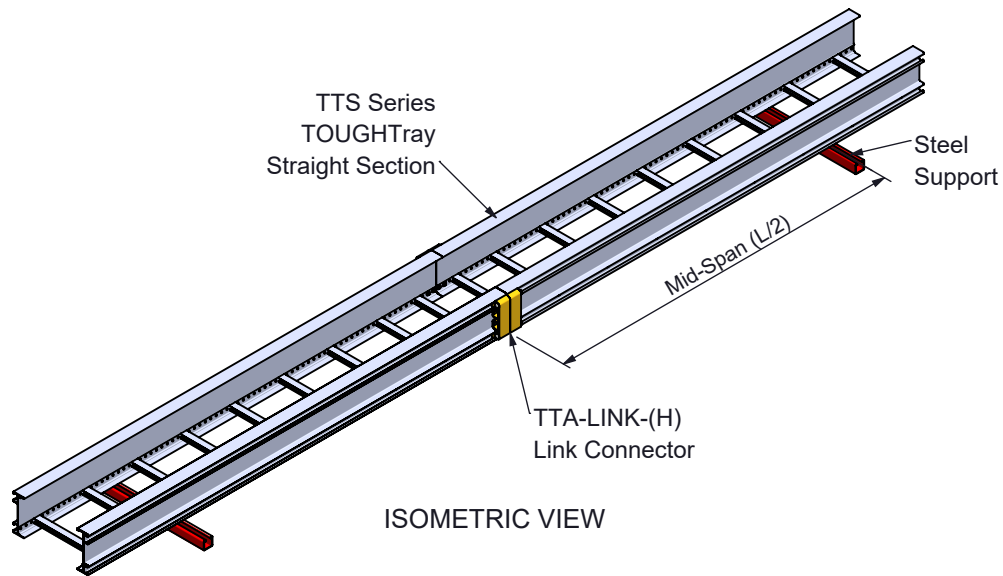
When the supports are placed at 1/4 Span ($L/4$) the following benefits are achieved:

1. Optimal Load Transfer: The $L/4$ position enables more efficient and effective load transfer between the different tray runs, reducing the deflection on the cable tray system compared to the splice positioned on the supports or at mid-span.
2. Increased Structural Efficiency: By placing connections at the $L/4$, the structural efficiency of the cable tray is increased as the splice connections experience minimum bending stress, as shown in the moment diagram.

FIGURE 1: 1/4 Span ($L/4$)



TOUGHTray Connecting LINKs Location

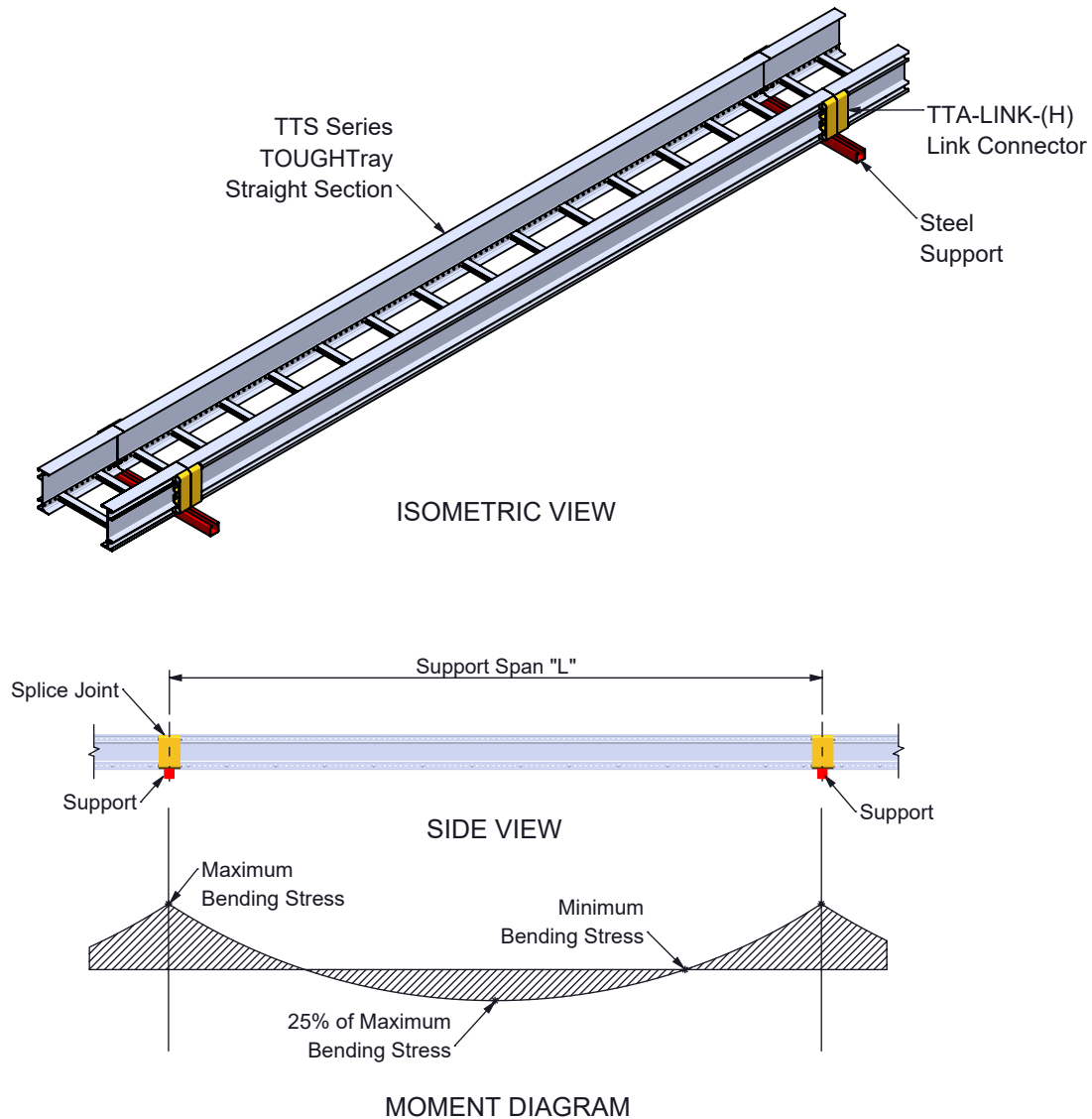


When the supports are placed at 1/2 Span ($L/2$) the cable tray system will be subject to an excessive deflection. In addition, the splice plates will also experience the (+) maximum bending stress as detailed in the above moment diagram which will greatly affect the structural integrity of the cable tray system.

FIGURE 2: Mid-Span ($L/2$)



TOUGHTray Connecting LINKs Location



Placing support underneath the splice plate would lead to an excessive stress on the connection, given that the (-) maximum bending stress occurs at these points, as illustrated in the moment diagram above. The maximum deflection will also be observed since load transfer between runs is less efficient when compared to splice connections positioned at the L/4. Locating the support underneath the splice plate can also cause interference between the splice plate and hold down clamp/expansion guide during thermal expansion and contraction.

FIGURE 3: Simple Beam (Support Underneath the Splice Joint)



**TOUGHTray Connecting LINKs
Location Finite Element Analysis**

Splice Joints Location	Stress and Deflection
At Support Location	<p>Maximum</p> <p>Minimum</p>
Mid-Span	
1/4 Span	

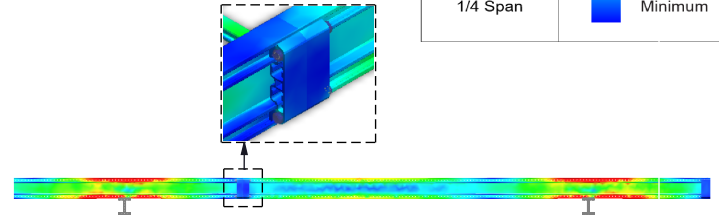
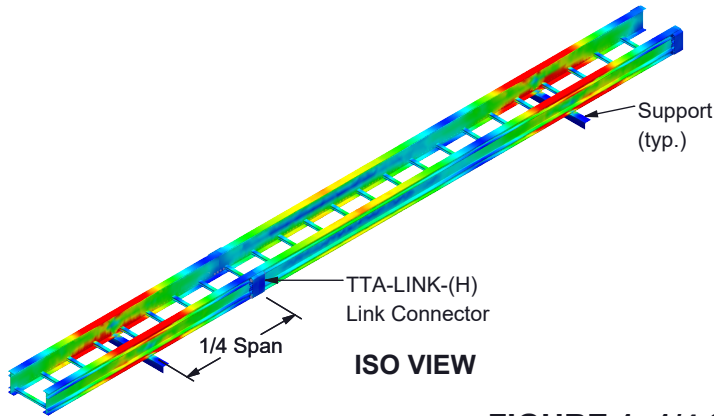


FIGURE 1: 1/4 Span (L/4)

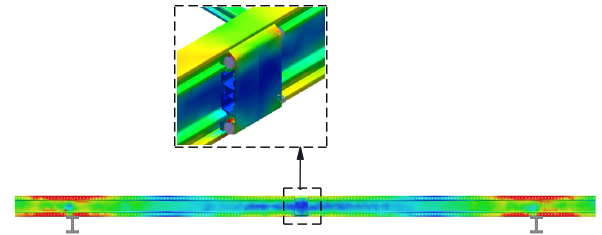
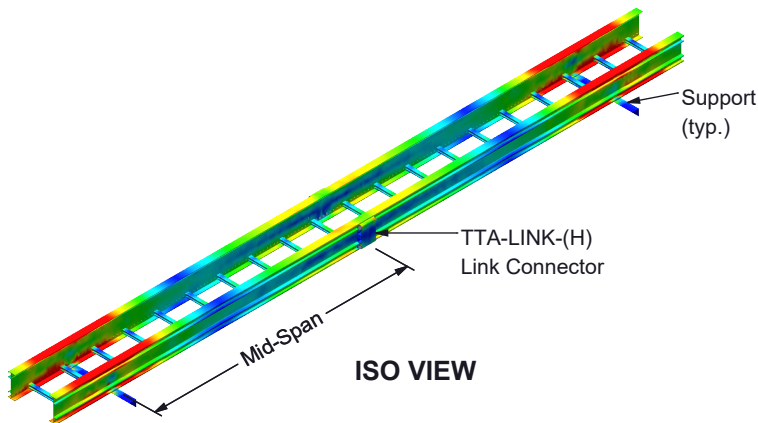


FIGURE 2: Mid-Span (L/2)

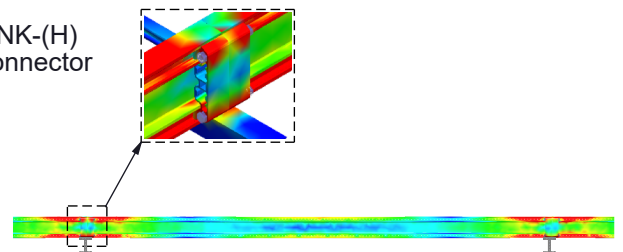
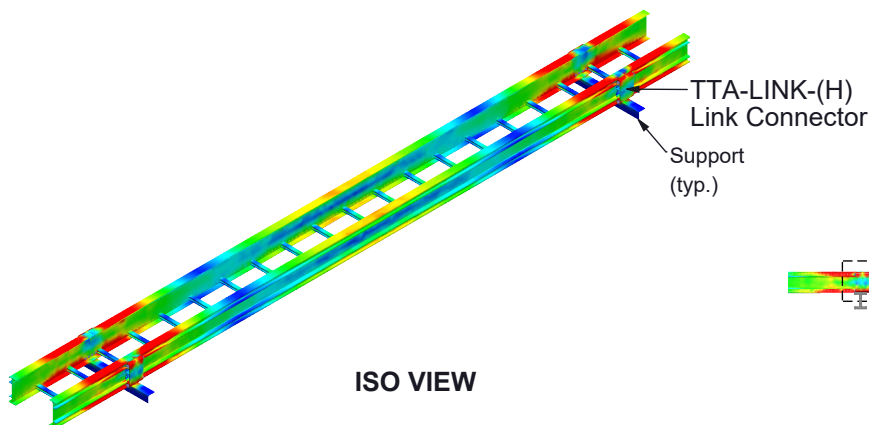
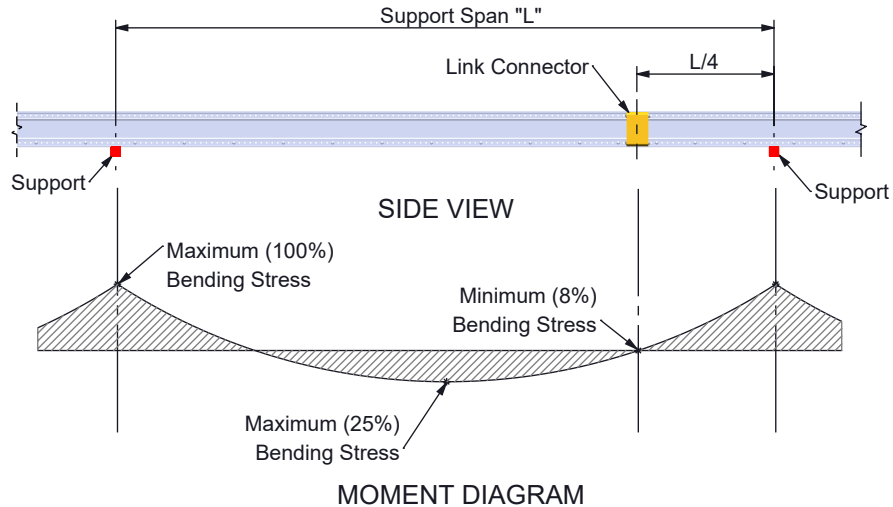
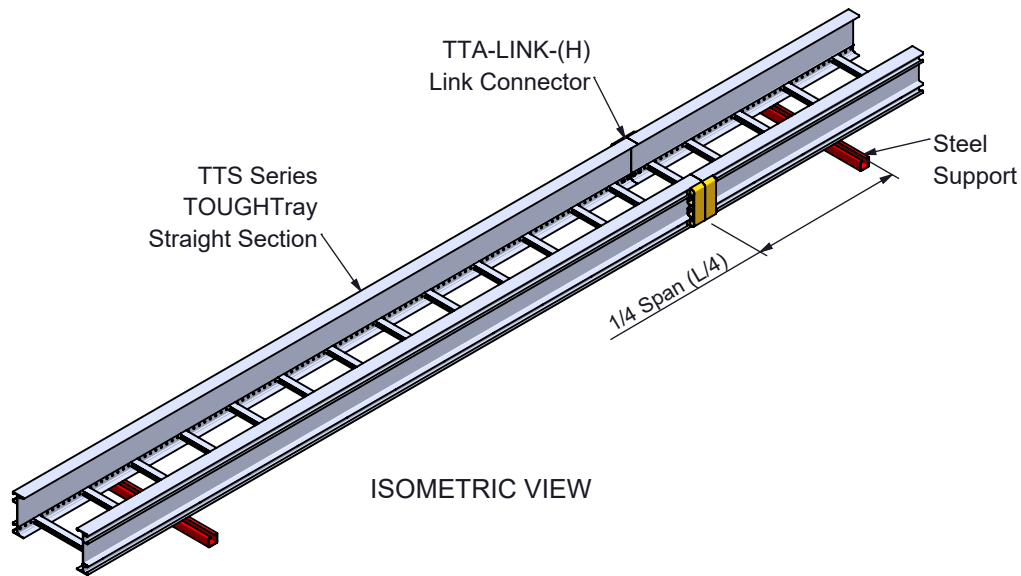


FIGURE 3: Simple Beam (Support Underneath the LINK Connectors)



TOUGHTray Link Connector Location



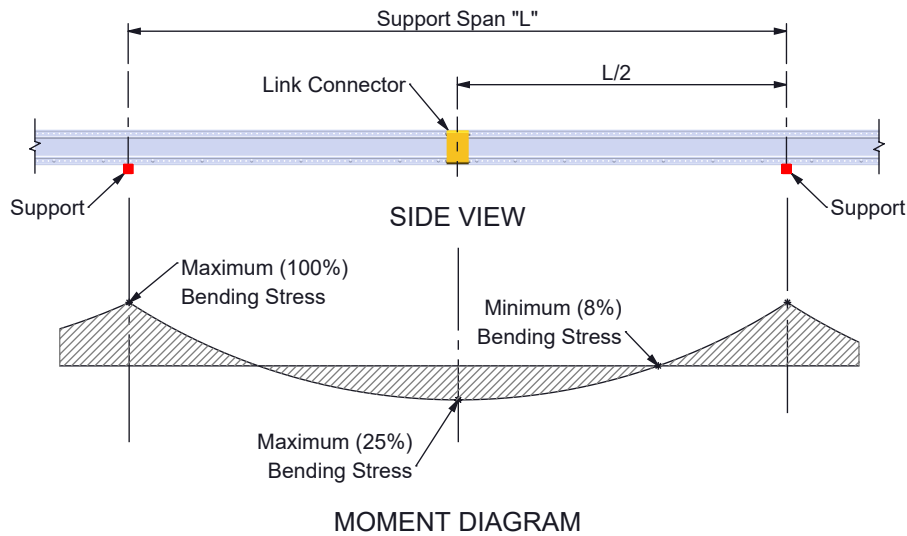
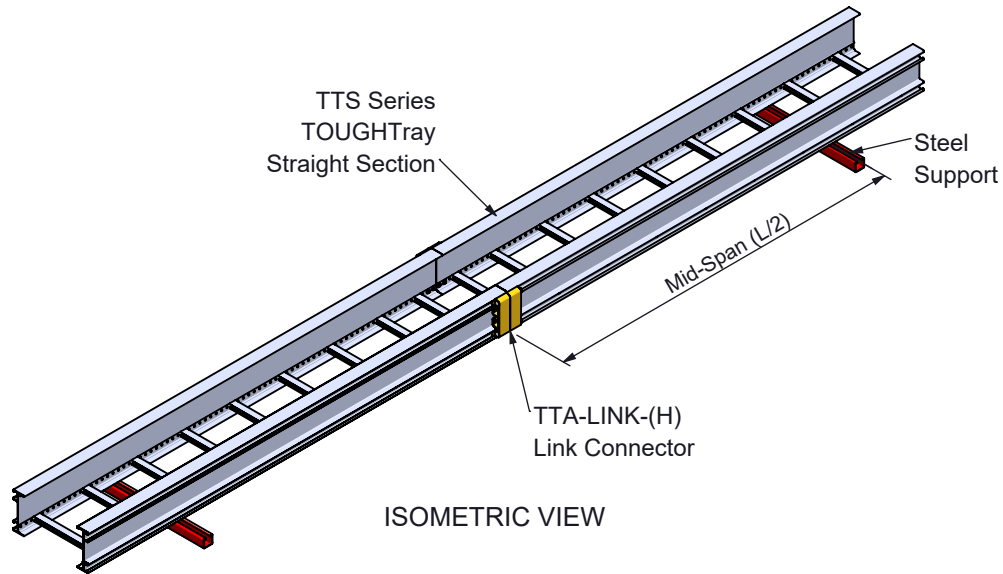
When the supports are placed at 1/4 Span (L/4) the following benefits are achieved:

1. Optimal Load Transfer: The L/4 position enables more efficient and effective load transfer between the different tray runs, reducing the deflection on the cable tray system compared to the link connectors positioned on the supports or at mid-span.
2. Increased Structural Efficiency: By placing link connectors at the L/4, the structural efficiency of the cable tray is increased as the link connections experience minimum bending stress, as shown in the moment diagram.

FIGURE 1: 1/4 Span (L/4)



TOUGHTray Link Connector Location

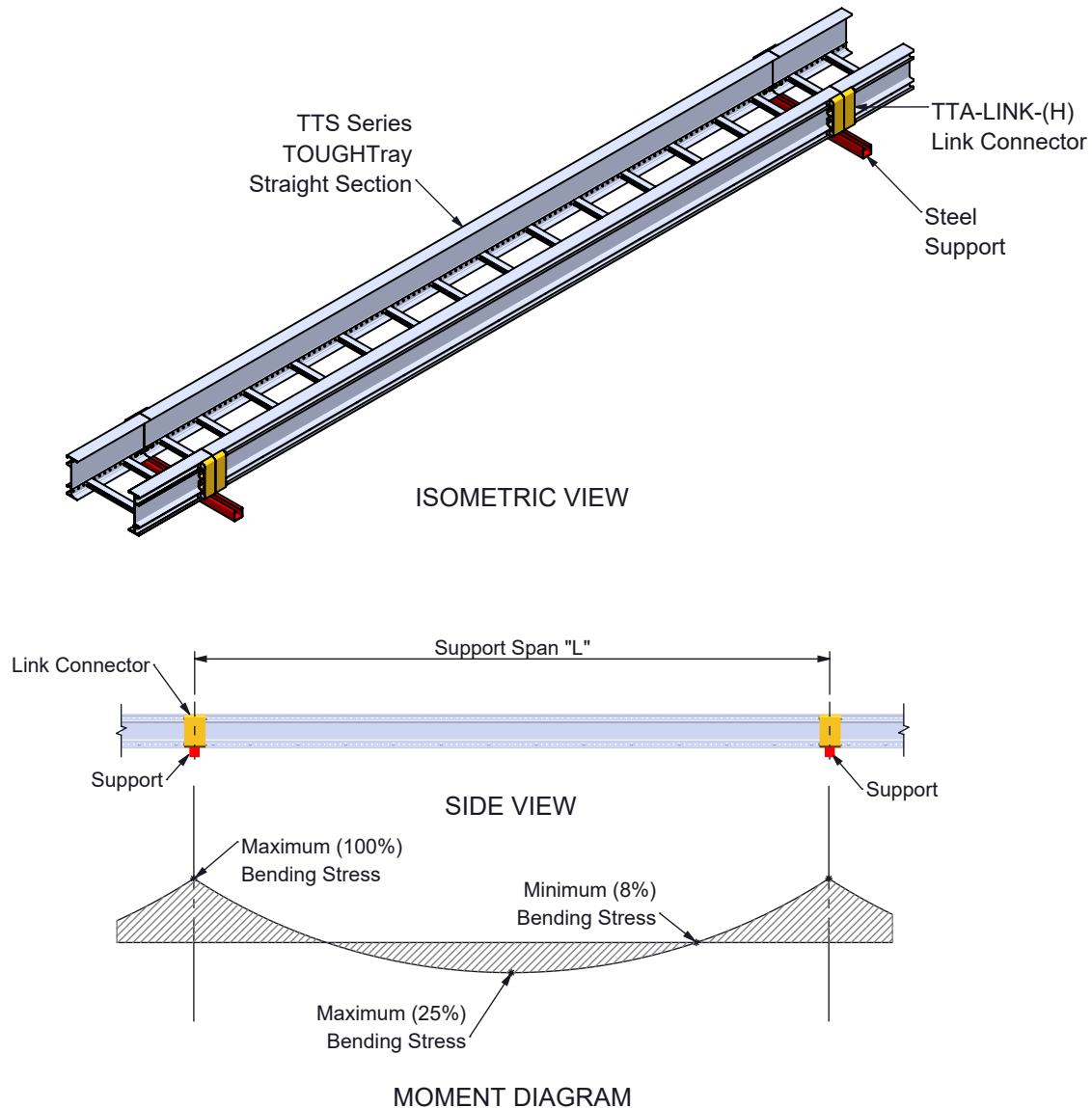


When the supports are placed at 1/2 Span ($L/2$) the cable tray system will be subject to an excessive deflection. In addition, the link connector will also experience the 25% of the maximum bending stress as detailed in the above moment diagram which will greatly affect the structural integrity of the cable tray system.

FIGURE 2: Mid-Span ($L/2$)



TOUGHTray Link Connector Location



Placing support underneath the link connectors would lead to an excessive or maximum 100% bending stress on the connections as detailed in the moment diagram above. The maximum deflection will also be observed since load transfer between runs is less efficient when compared to link connectors positioned at the L/4. Locating the support underneath the link connections can also cause interference between the link connector and hold down clamp/expansion guide during thermal expansion and contraction.

FIGURE 3: Simple Beam (Support Underneath the Link Connectors)



**TOUGHTray Link Connector Location
Finite Element Analysis**

Link Connector Location	Stress and Deflection
At Support Location	<p>Maximum</p> <p>Minimum</p>
Mid-Span	
1/4 Span	

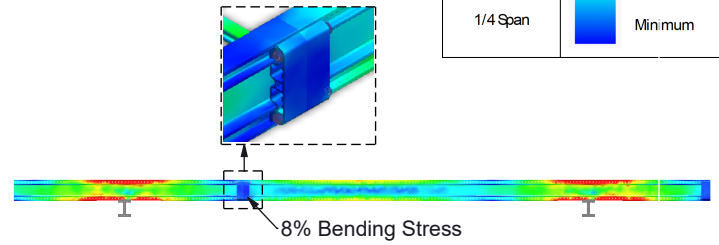
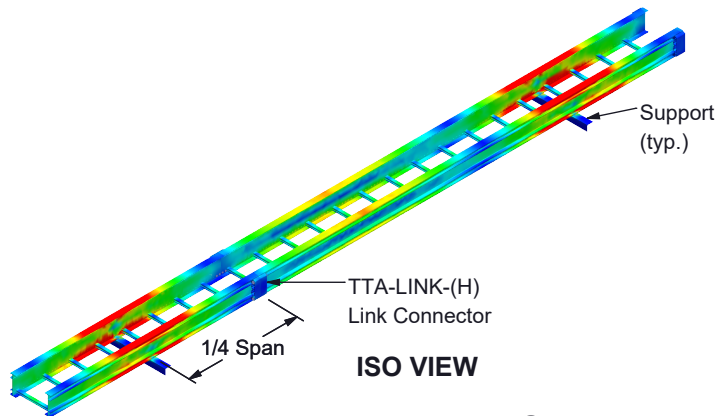


FIGURE 1: 1/4 Span (L/4)

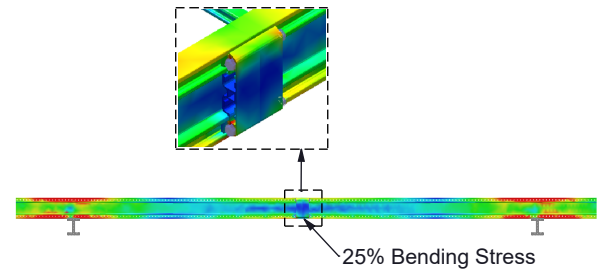
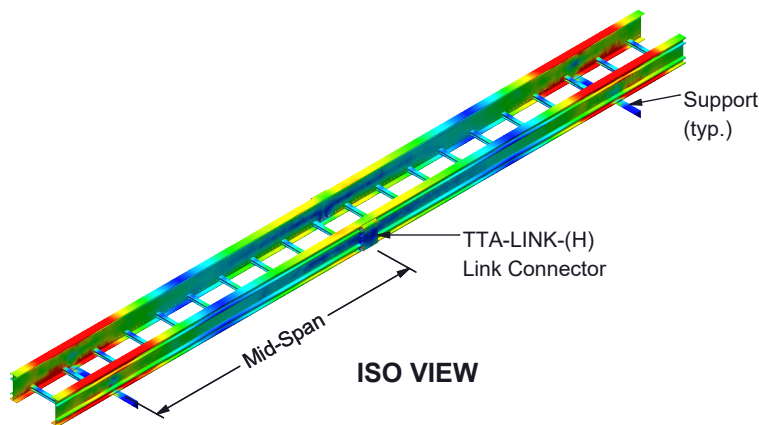


FIGURE 2: Mid-Span (L/2)

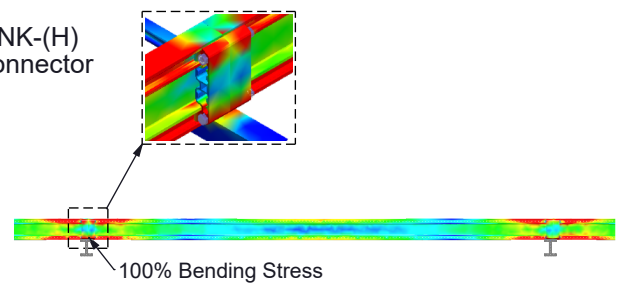
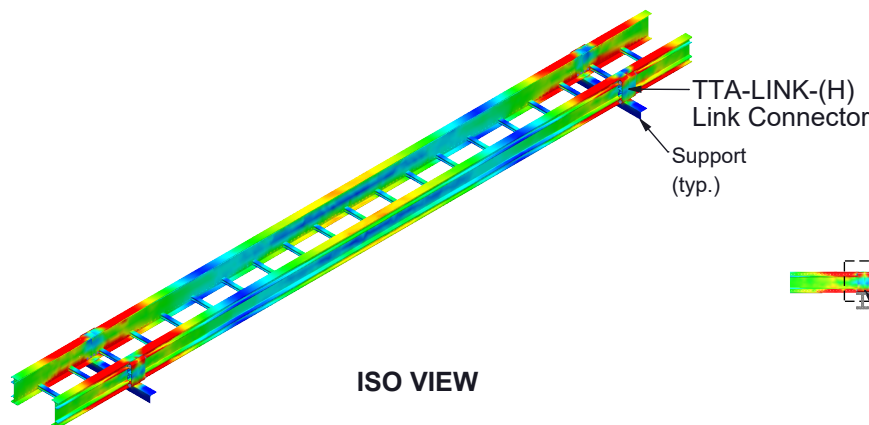
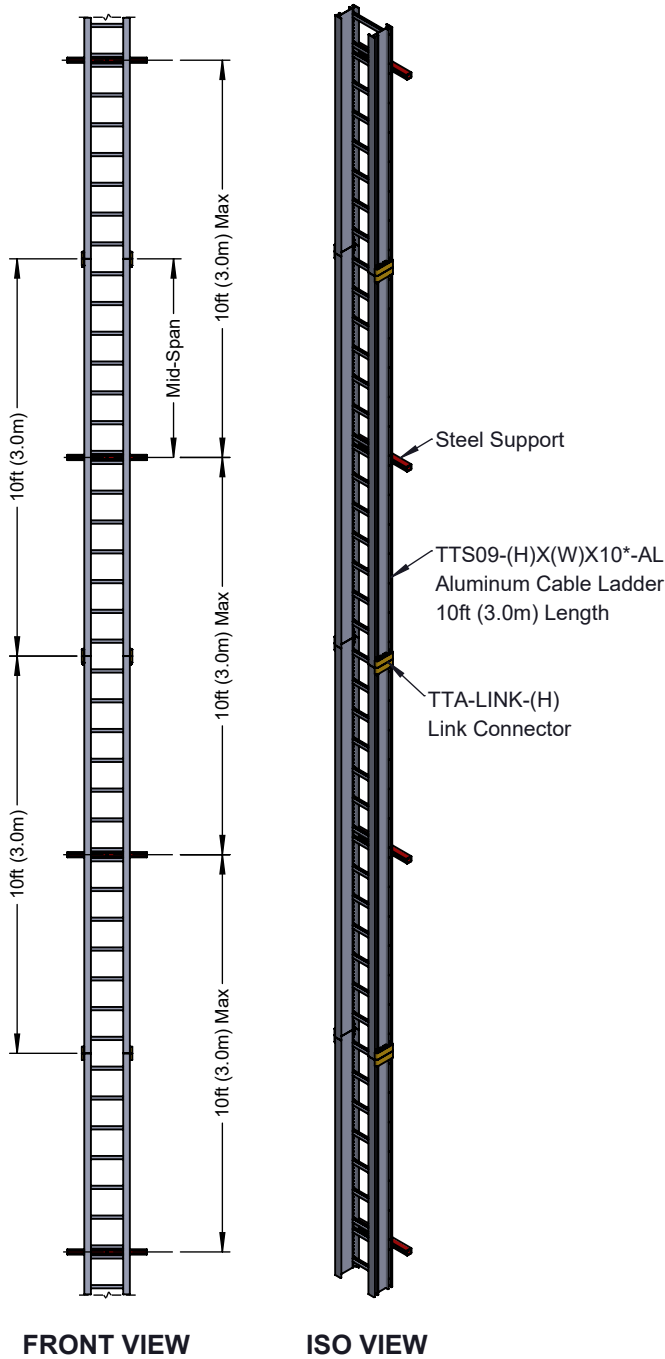


FIGURE 3: Simple Beam (Support Underneath the Link Connectors)

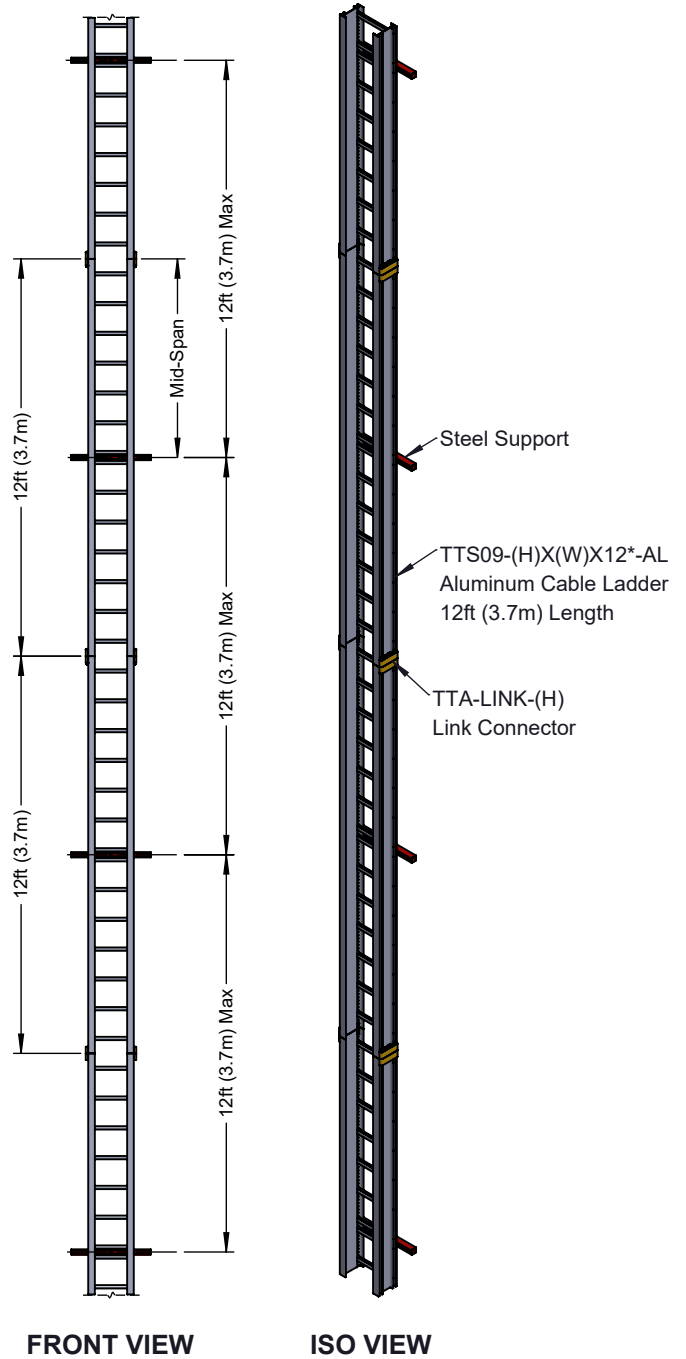


TOUGHTray Longer Span Optimization

(Vertical Cable Tray Run - Splice at Mid-Span)



**FIGURE 1: NEMA 10*
(NOT OPTIMIZED)**



**FIGURE 2: NEMA 12*
(MINIMAL OPTIMIZATION)**



TOUGHTray Longer Span Optimization

(Vertical Cable Tray Run - Splice at Mid-Span)

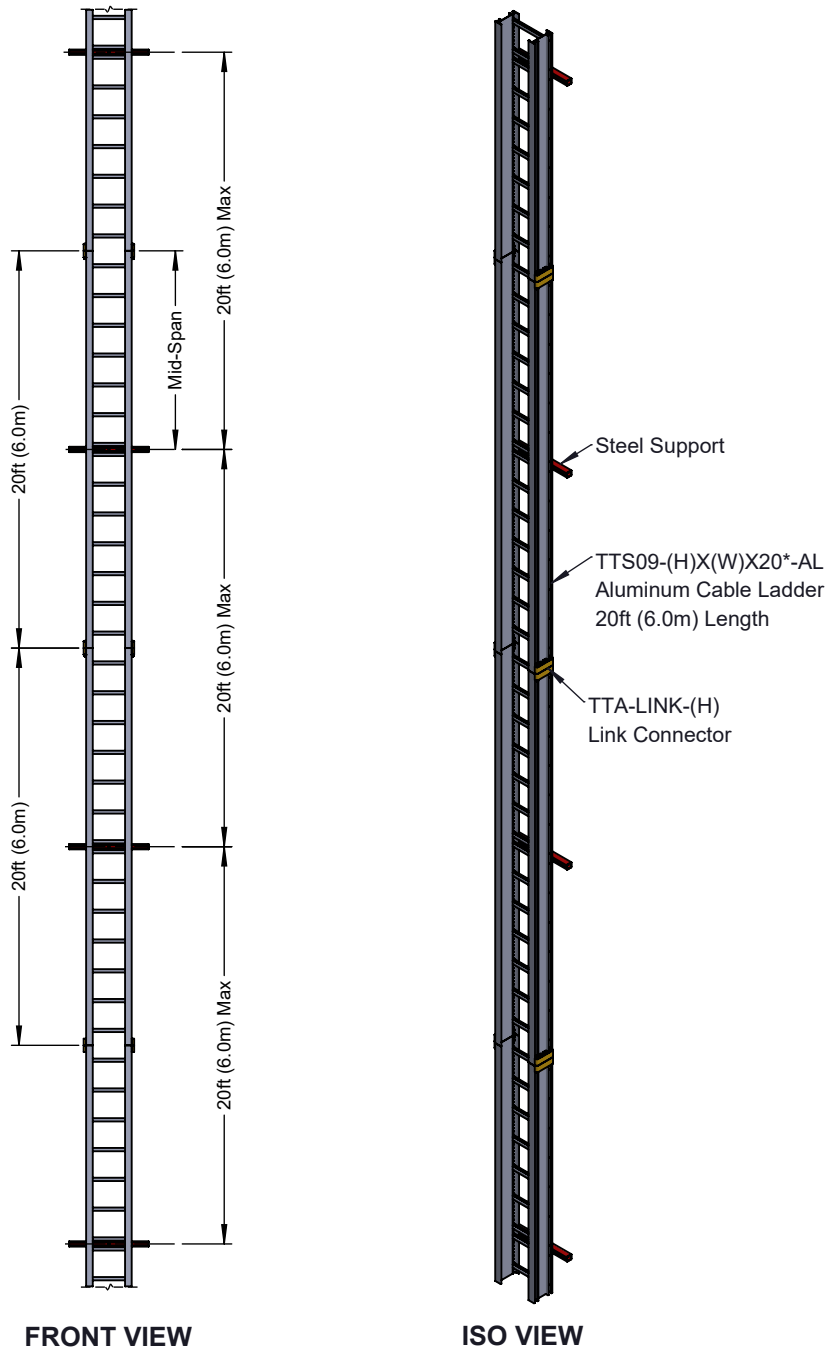
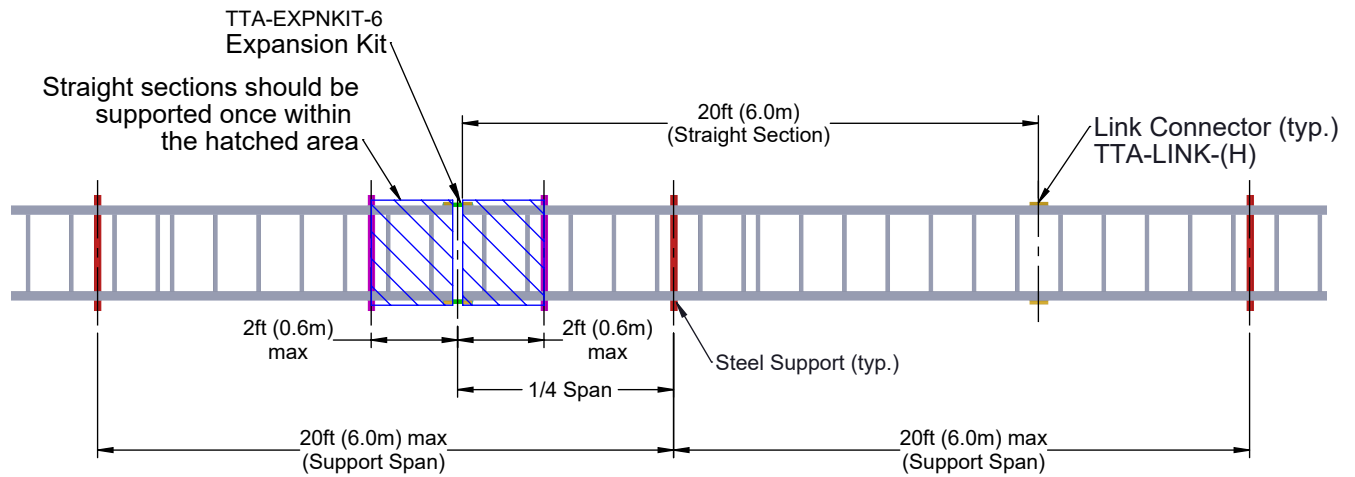


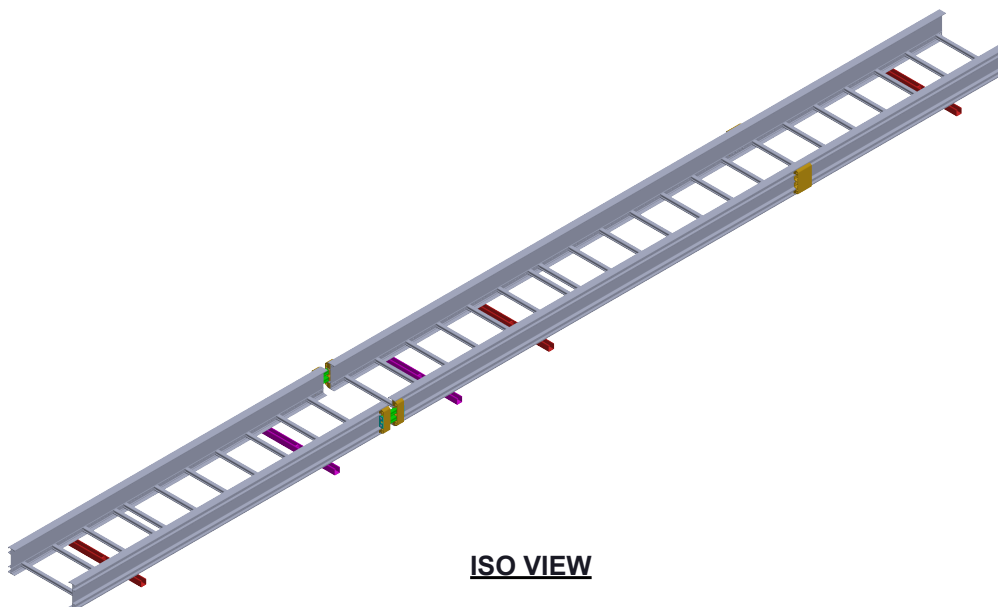
FIGURE 3: NEMA 20* (MAXIMUM OPTIMIZATION)



**TOUGH SUPPORT SAVINGS for TOUGHTray
HORIZONTAL EXPANSION CONNECTOR**



PLAN VIEW

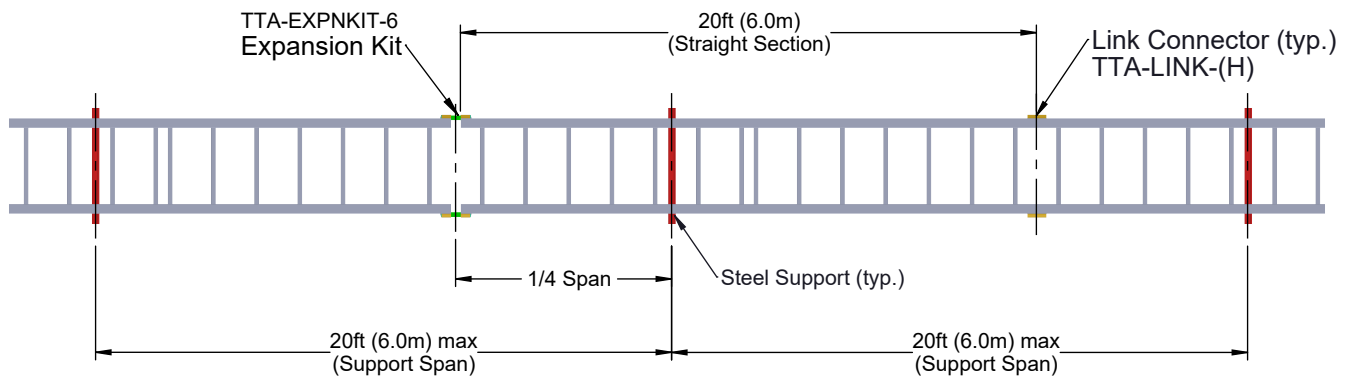


ISO VIEW

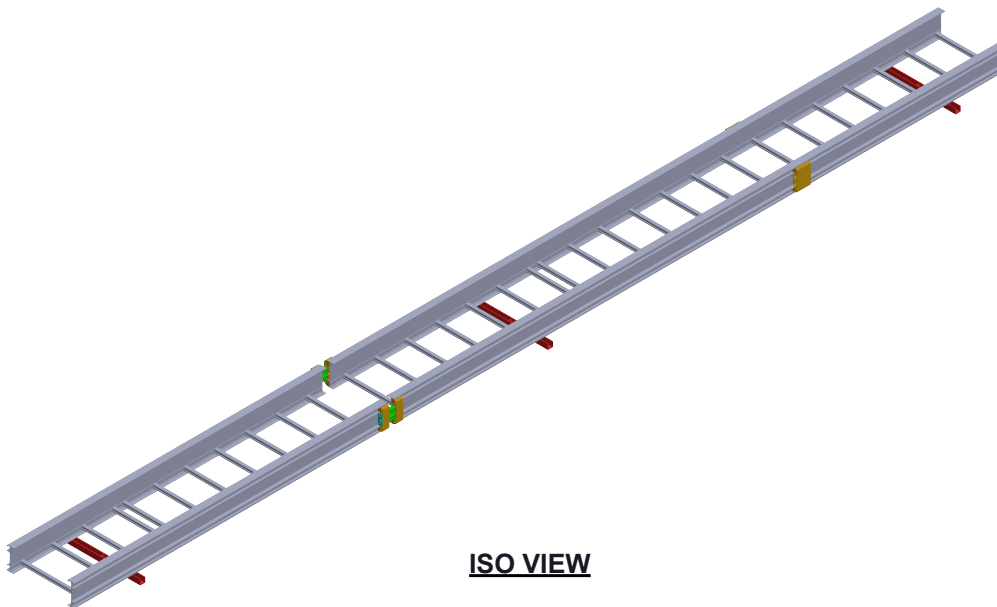
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
HORIZONTAL EXPANSION CONNECTOR**



PLAN VIEW



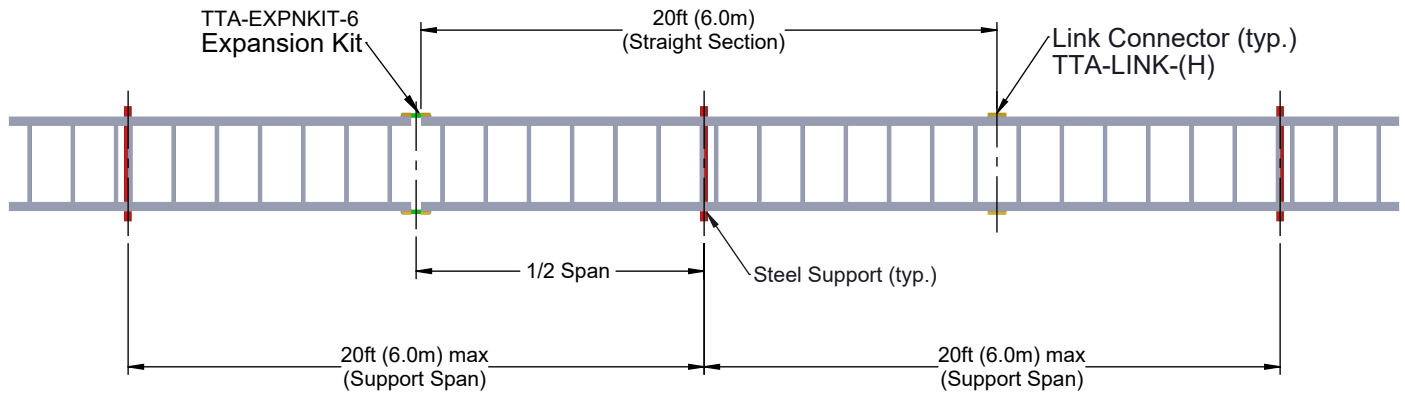
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

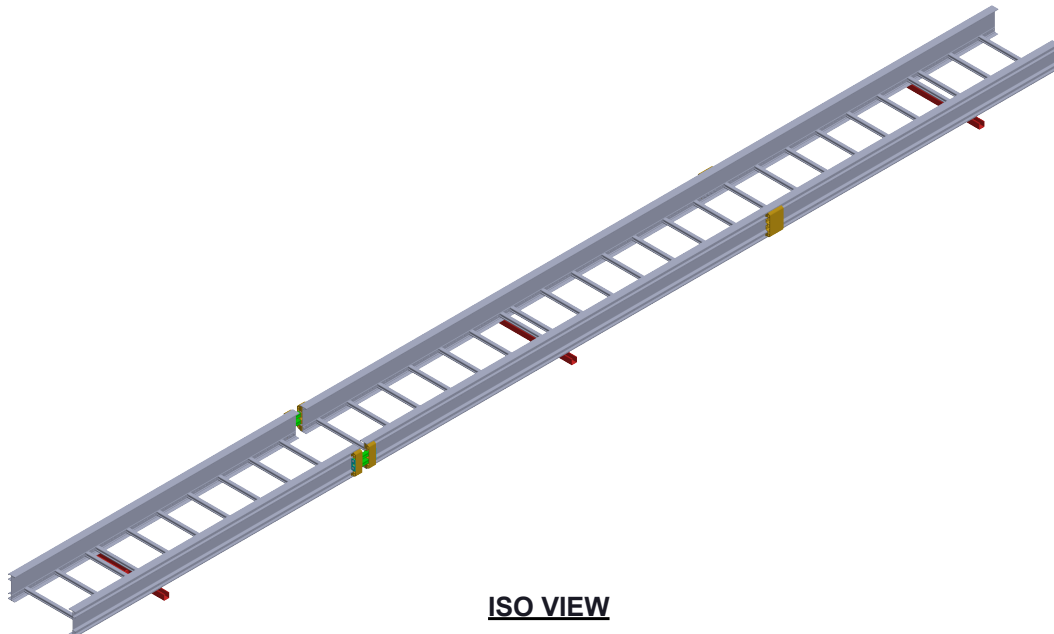
FIGURE 2: 1/4 SPAN SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
HORIZONTAL EXPANSION CONNECTOR**



PLAN VIEW



ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 3: 1/2 SPAN SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
VERTICAL EXPANSION JOINT**

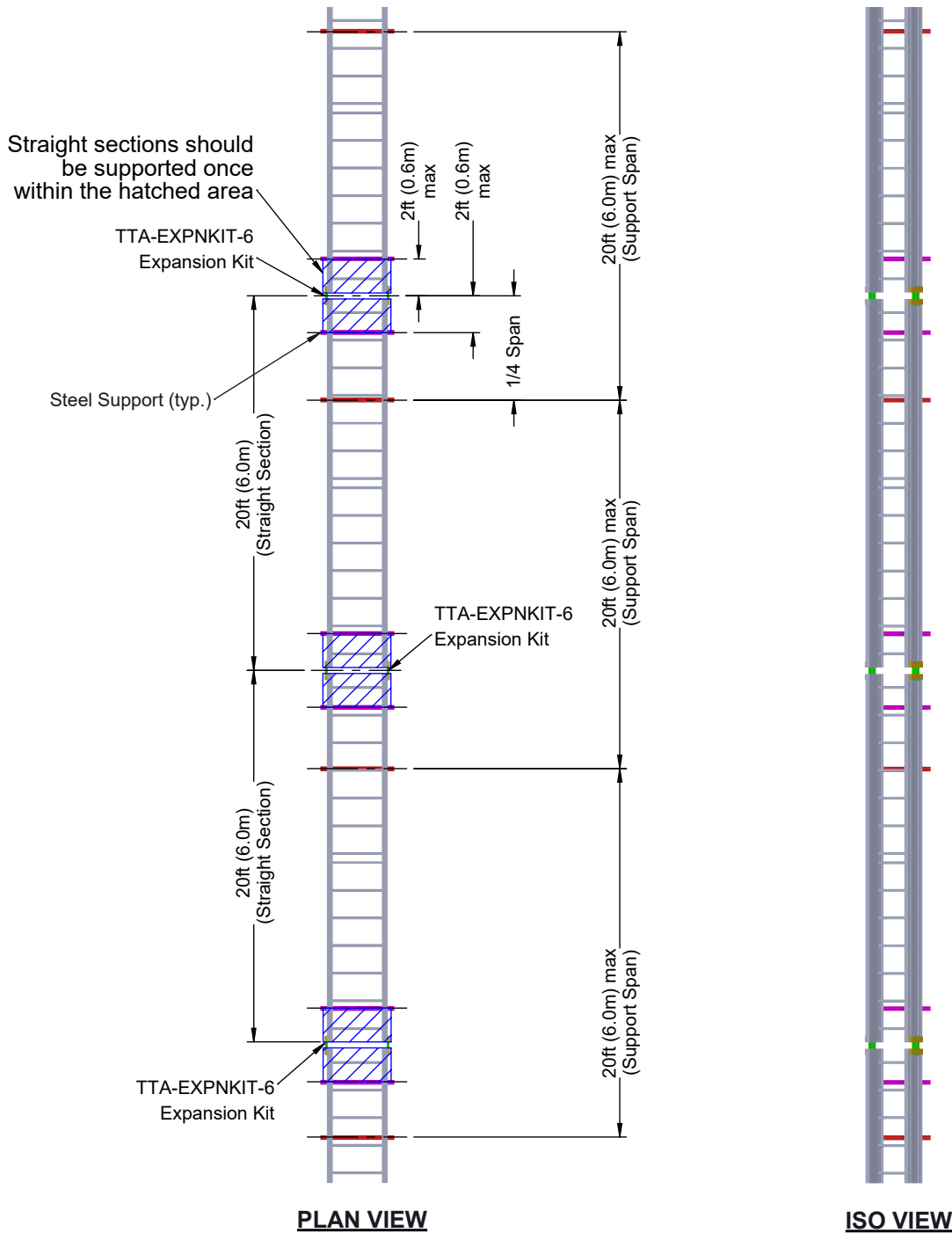


FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
VERTICAL EXPANSION JOINT**

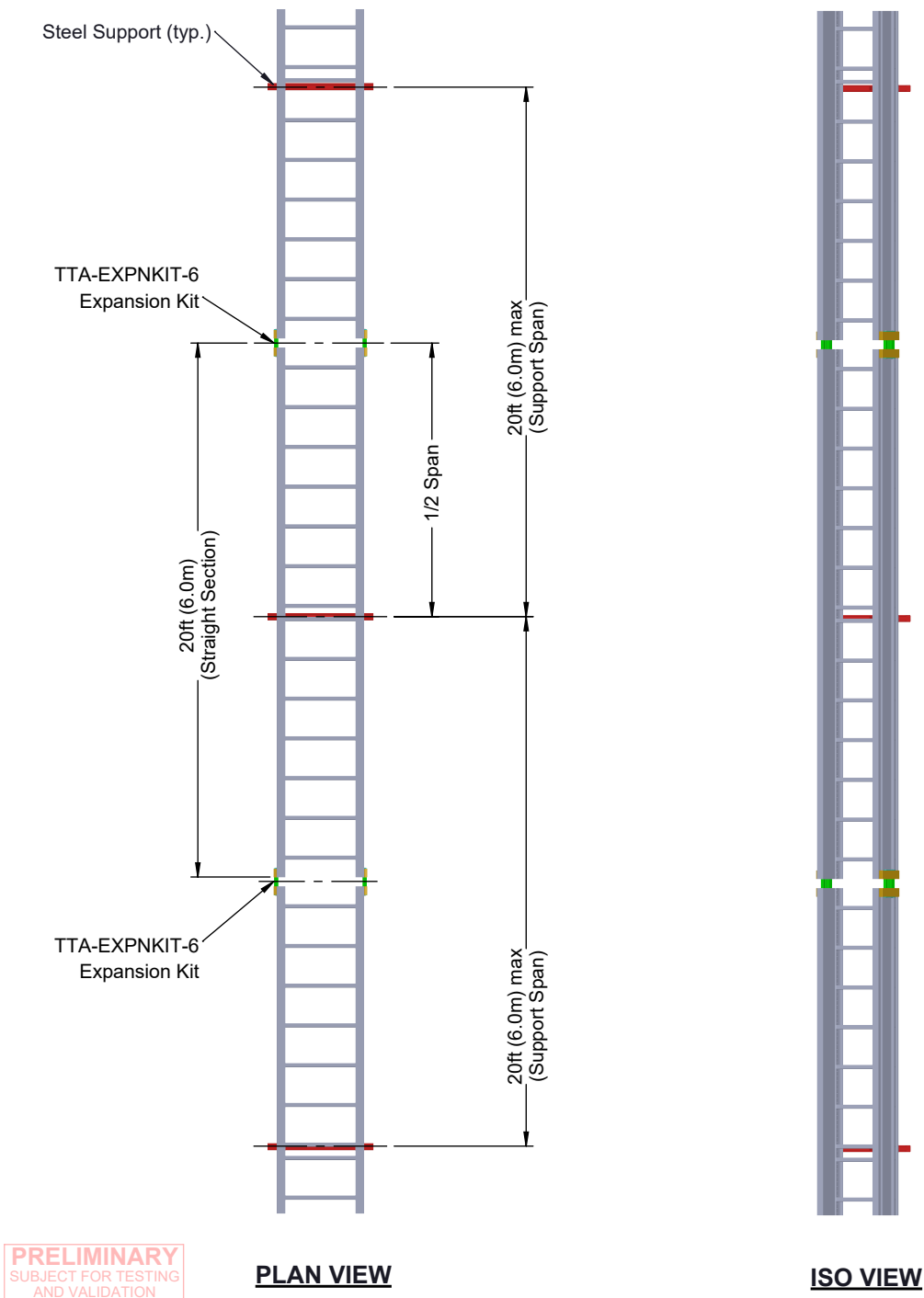
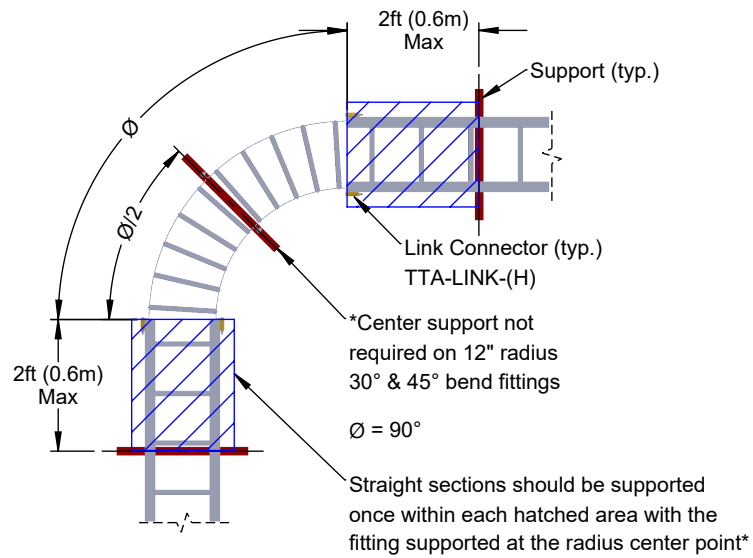


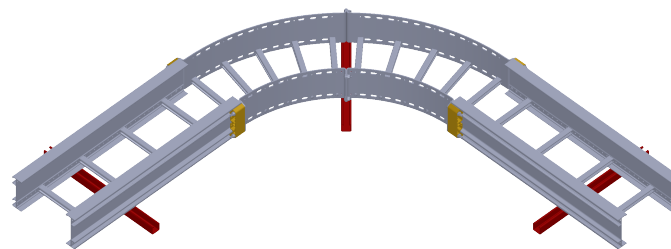
FIGURE 2: 1/2 SPAN SELF-SUPPORTING SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 90° Horizontal Bend



PLAN VIEW

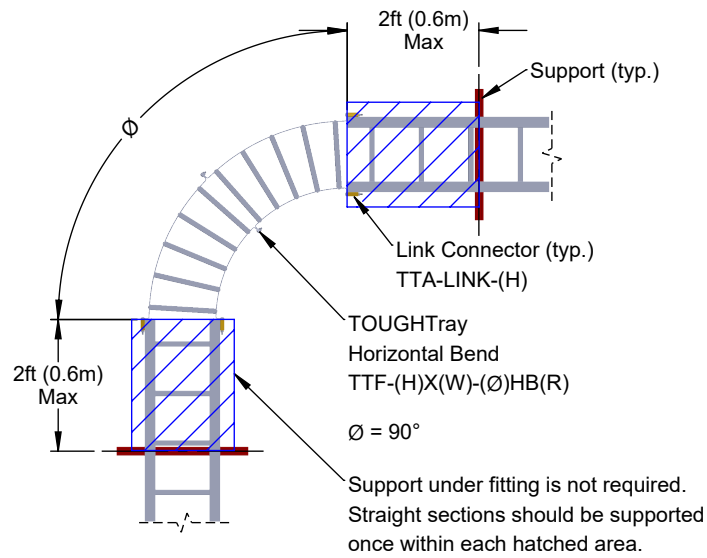


ISO VIEW

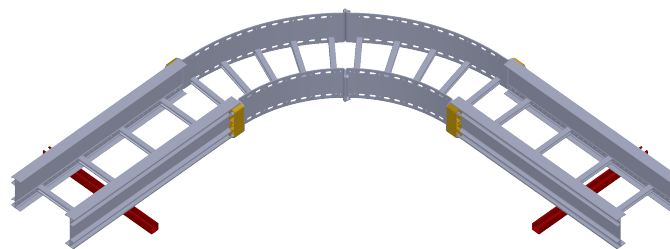
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 90° Horizontal Bend



PLAN VIEW

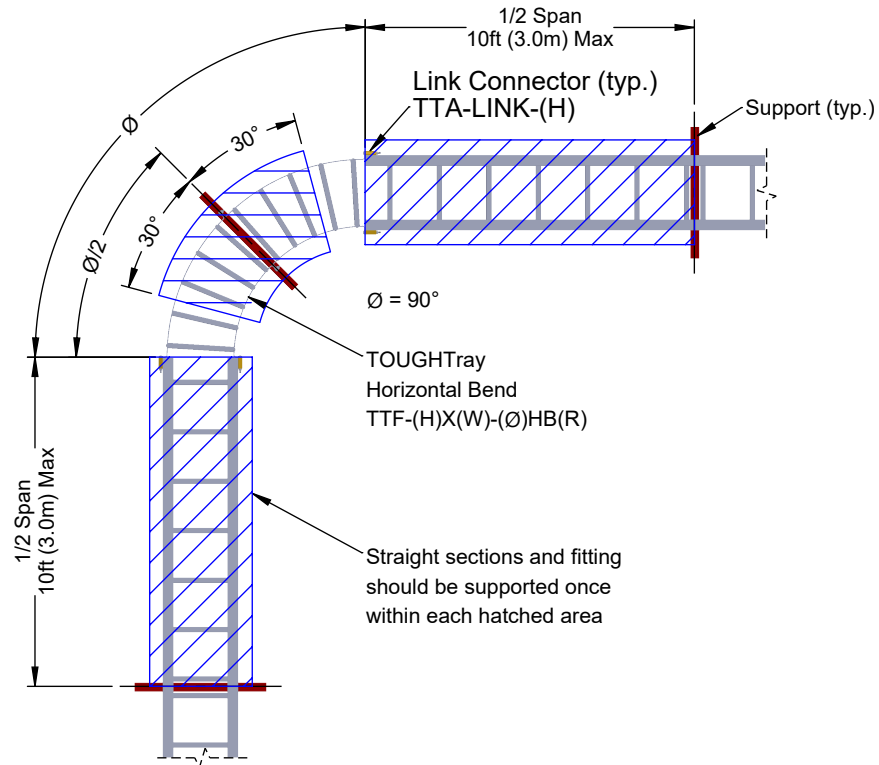


ISO VIEW

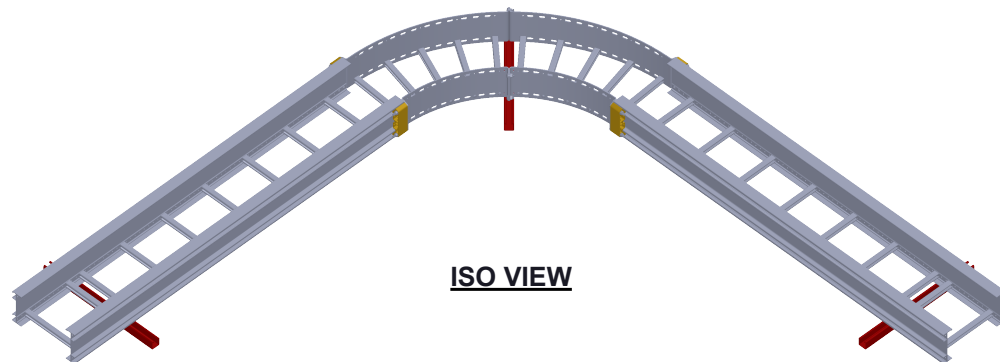
FIGURE 2: TOUGH SUPPORT SAVINGS
"UNSUPPORTED FITTING"



TOUGH SUPPORT SAVINGS for TOUGHTray 90° Horizontal Bend



PLAN VIEW

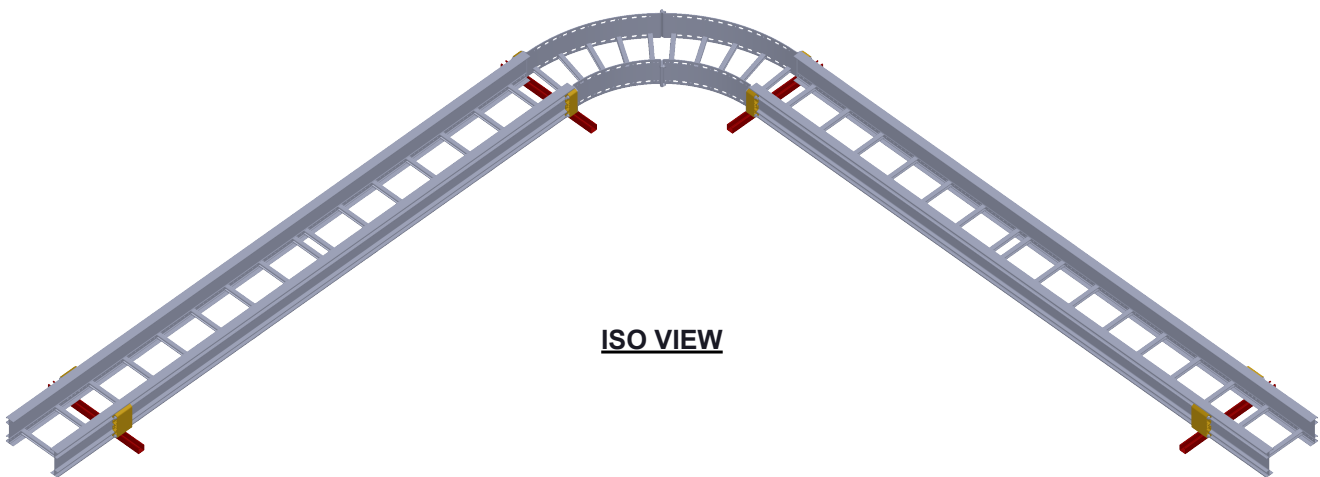
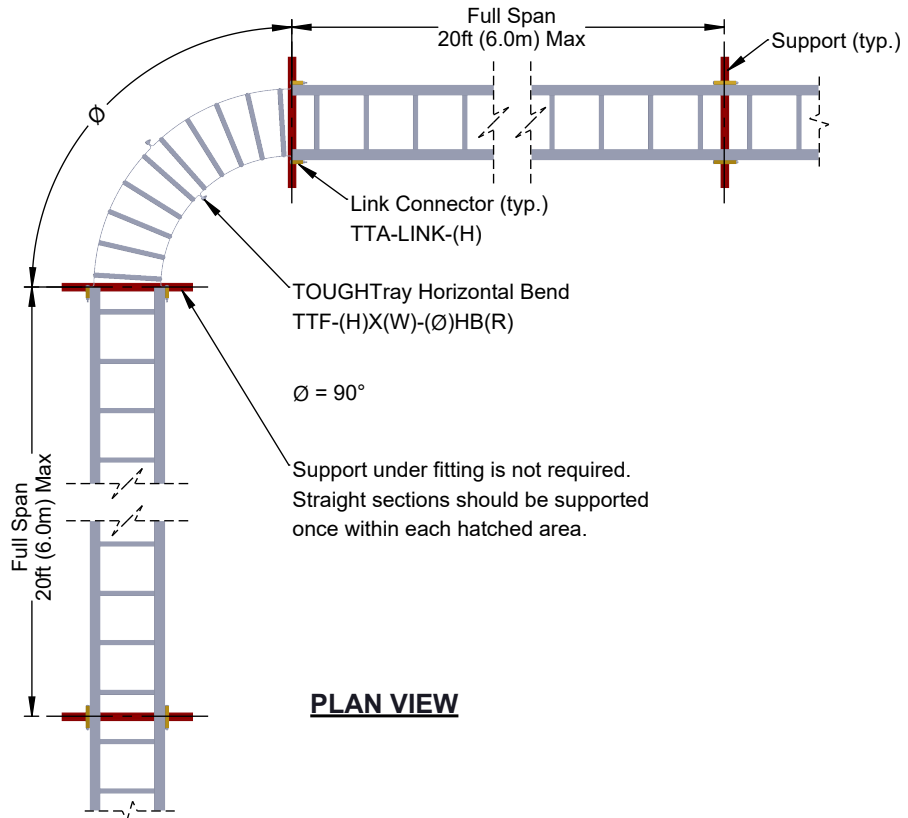


ISO VIEW

**FIGURE 3: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED"**



TOUGH SUPPORT SAVINGS for TOUGHTray 90° Horizontal Bend

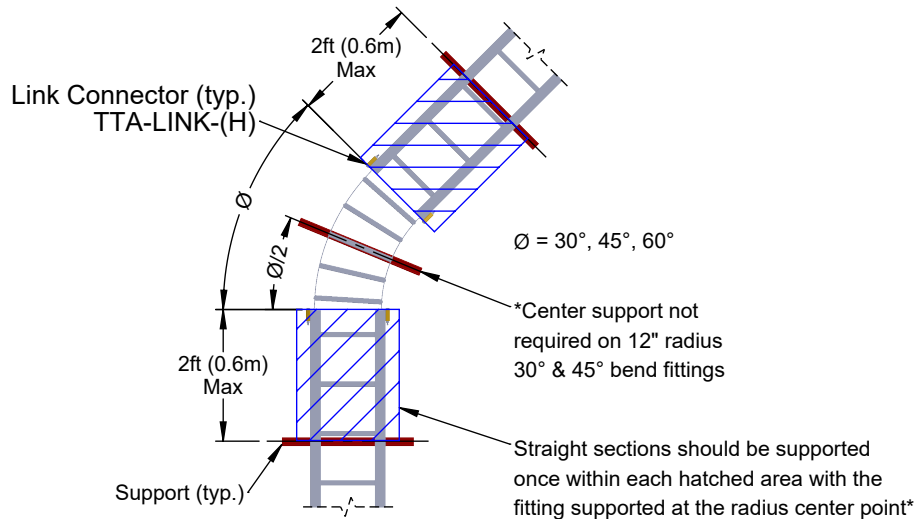


ISO VIEW

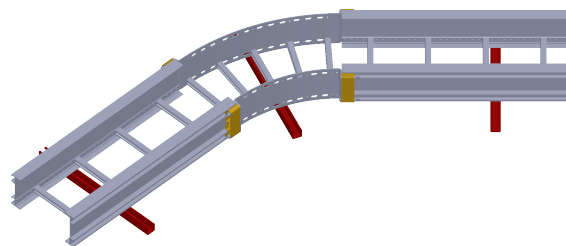
**FIGURE 4: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray 30°, 45°, 60° Horizontal Bend



PLAN VIEW

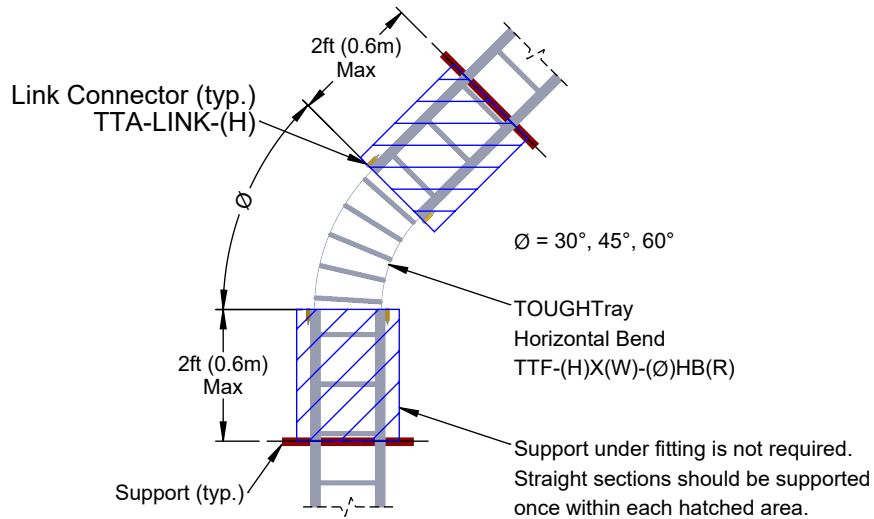


ISO VIEW

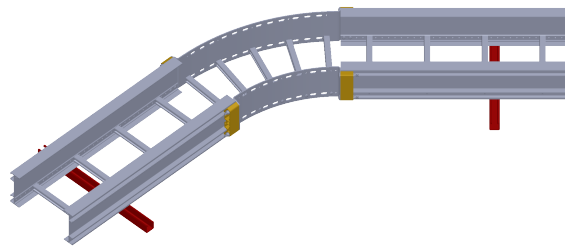
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 30°, 45°, 60° Horizontal Bend



PLAN VIEW



ISO VIEW

**FIGURE 2: TOUGH SUPPORT SAVINGS
"UNSUPPORTED FITTING"**



TOUGH SUPPORT SAVINGS for TOUGHTray 30°, 45°, 60° Horizontal Bend

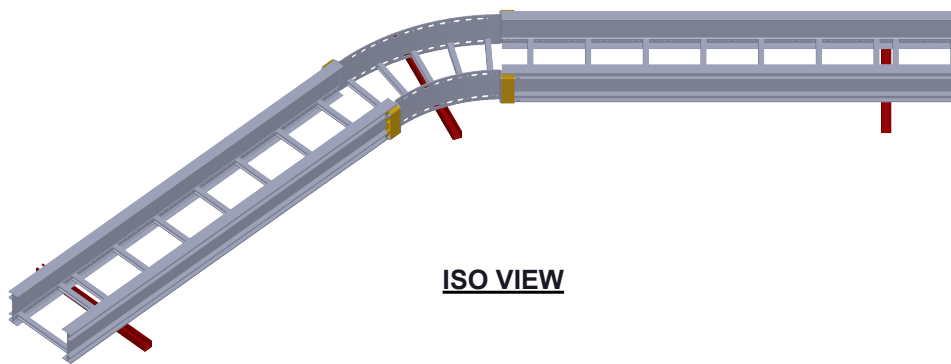
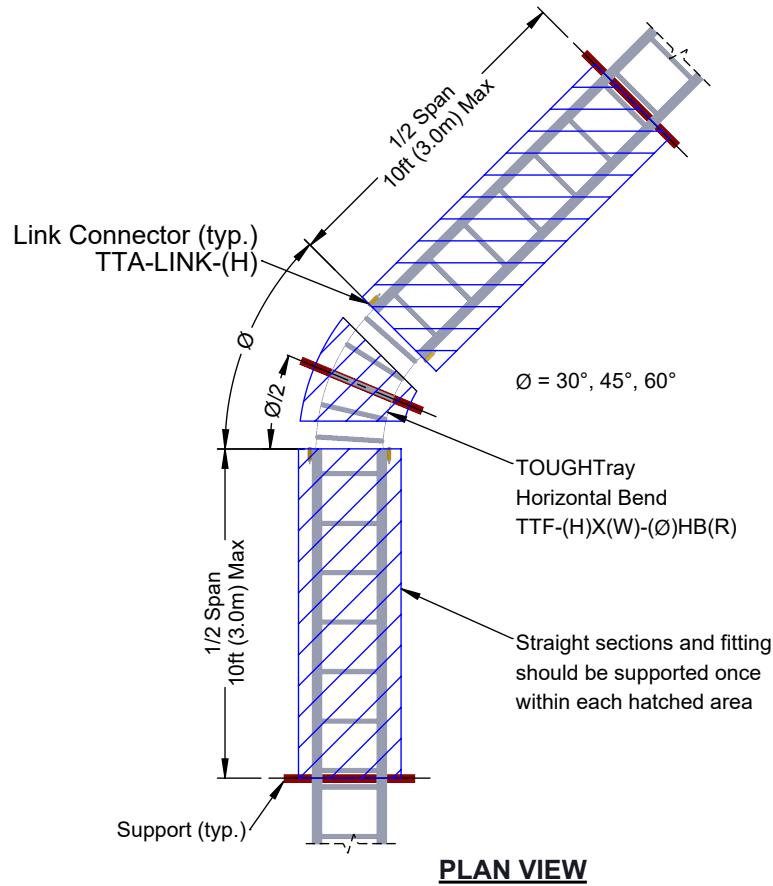
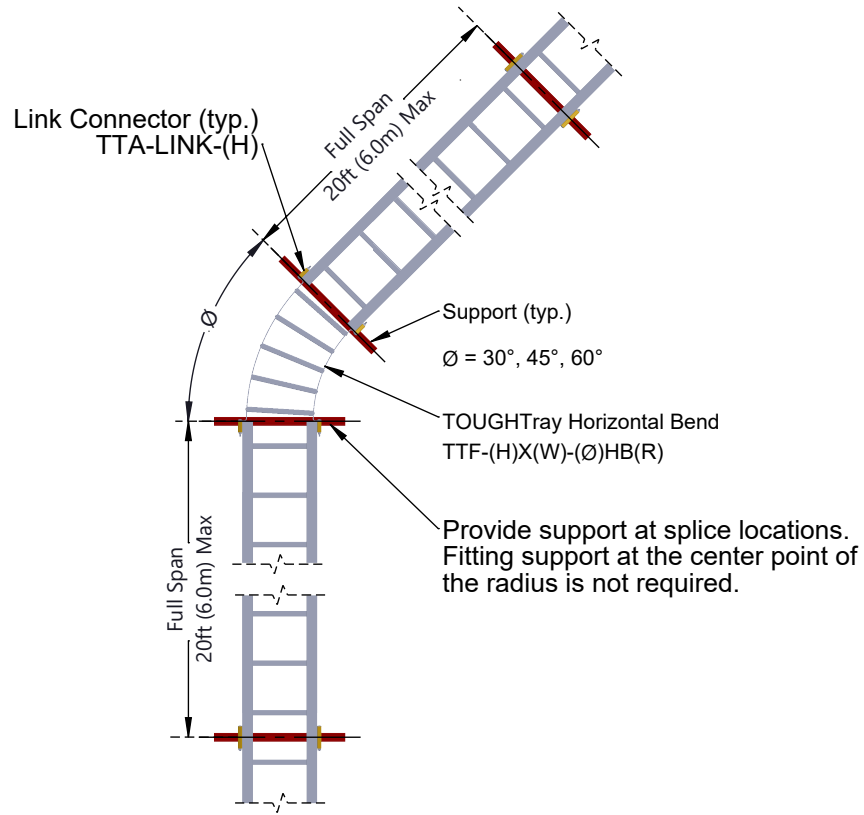


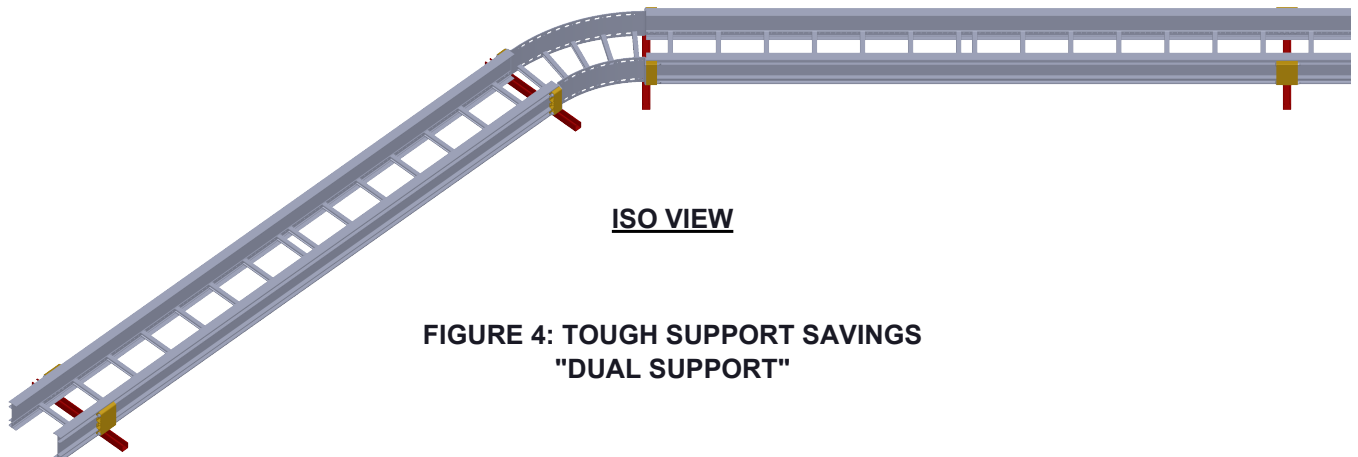
FIGURE 3: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED"



TOUGH SUPPORT SAVINGS for TOUGHTray 30°, 45°, 60° Horizontal Bend



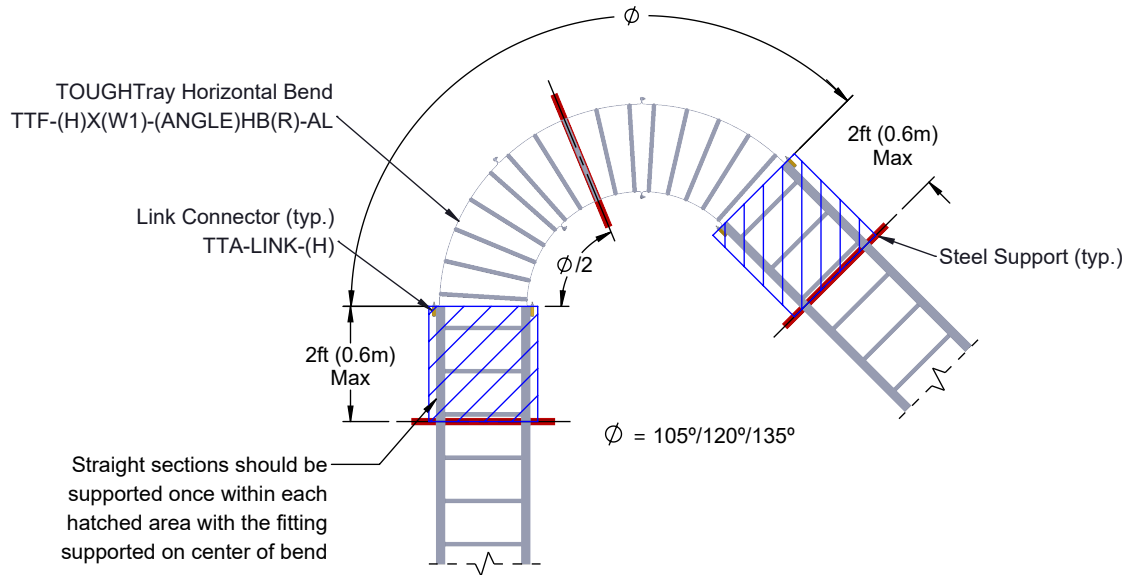
PLAN VIEW



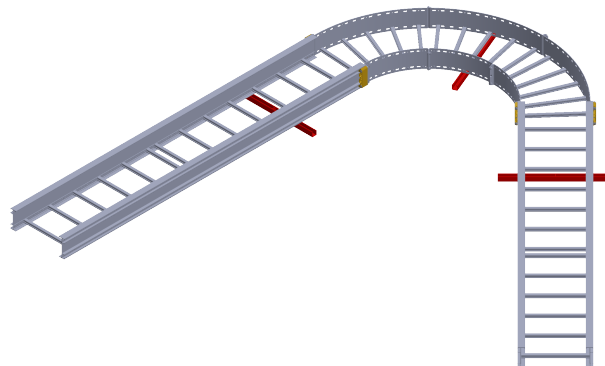
**FIGURE 4: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray 105°/120°/135° HORIZONTAL BEND SUPPORT



PLAN VIEW

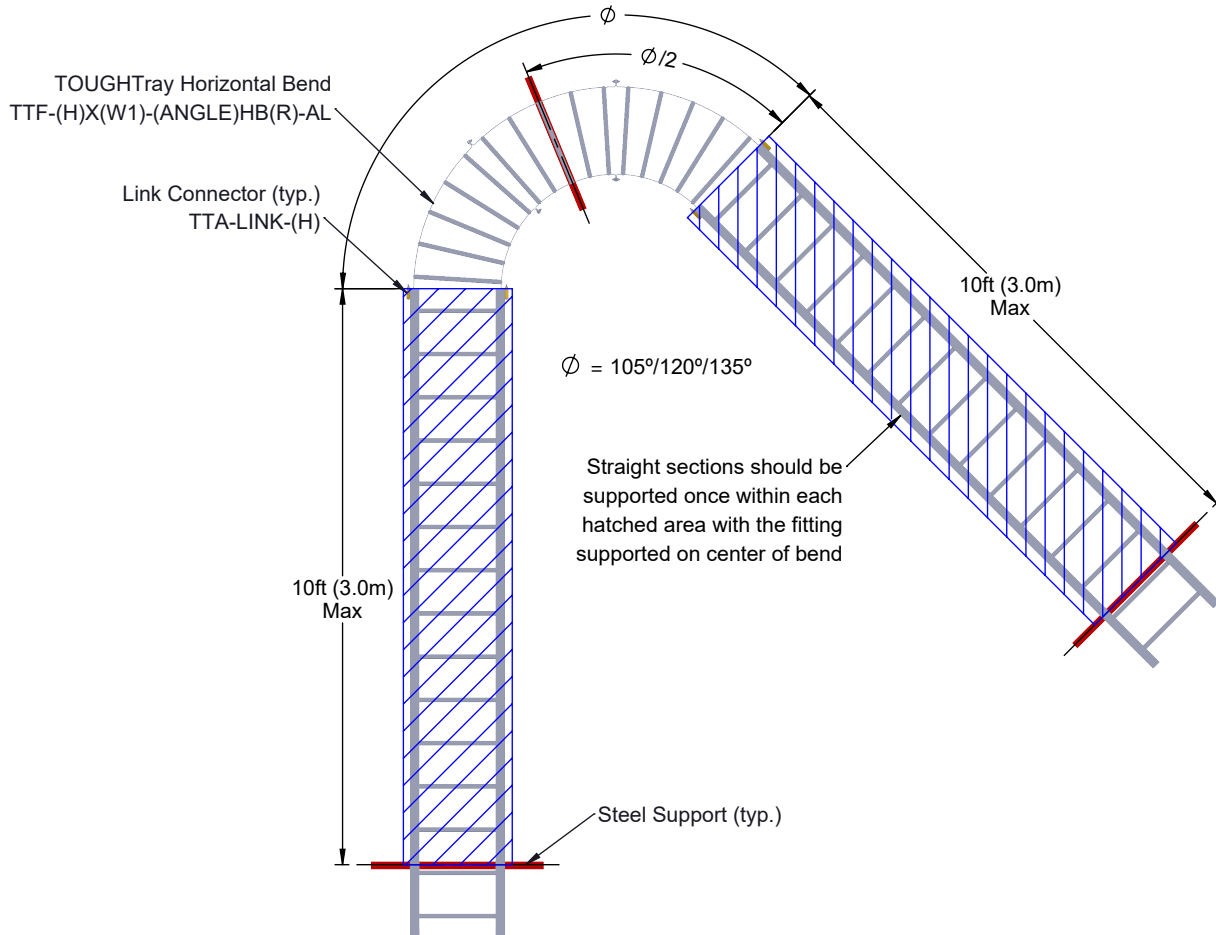


ISO VIEW

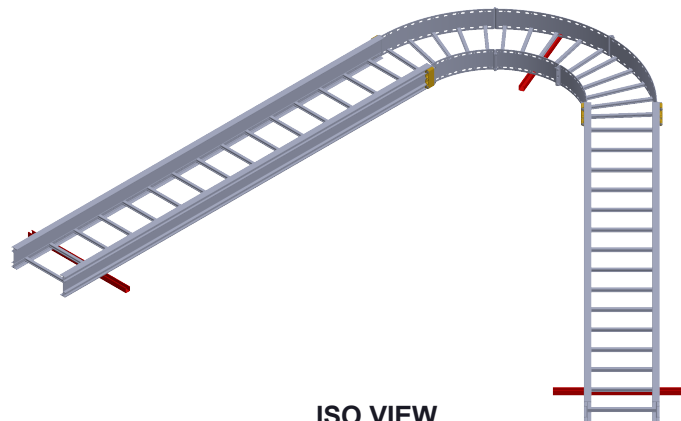
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 105°/120°/135° HORIZONTAL BEND SUPPORT



PLAN VIEW



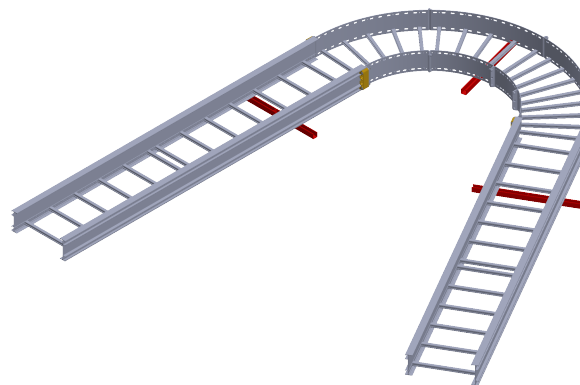
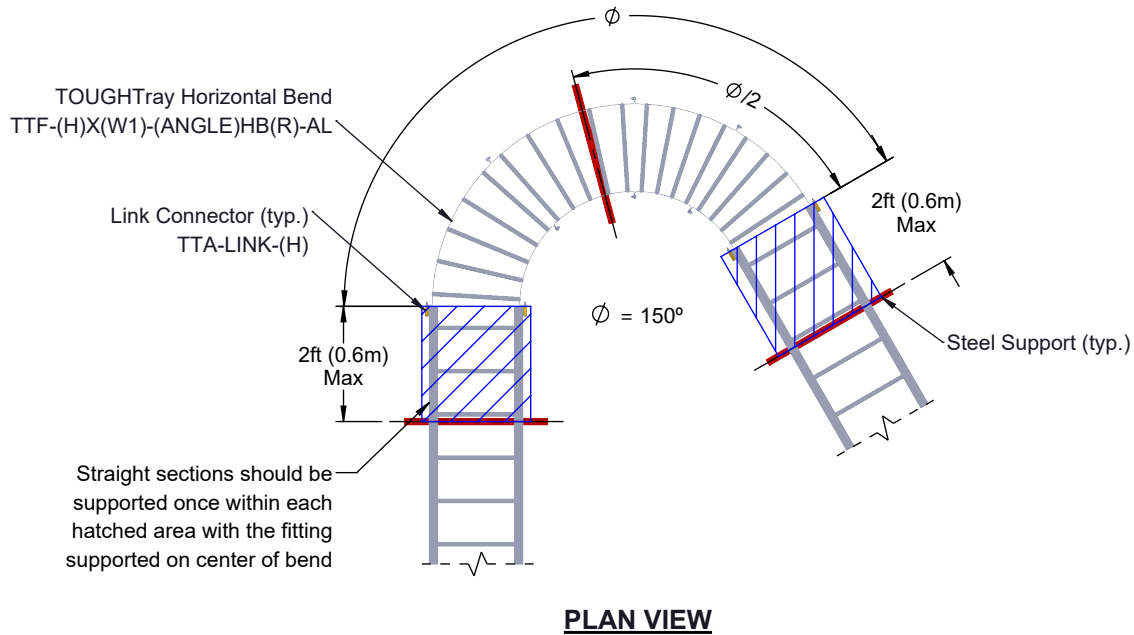
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 150° HORIZONTAL BEND SUPPORT

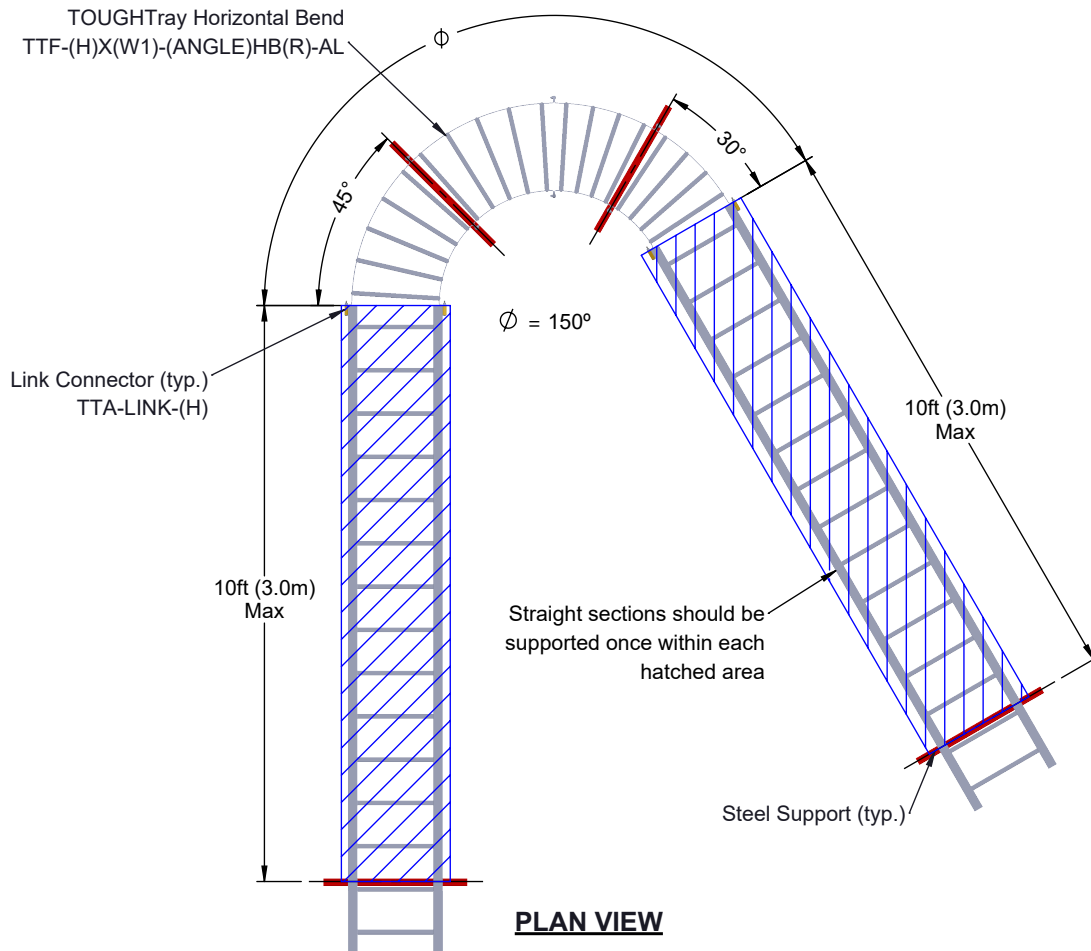


ISO VIEW

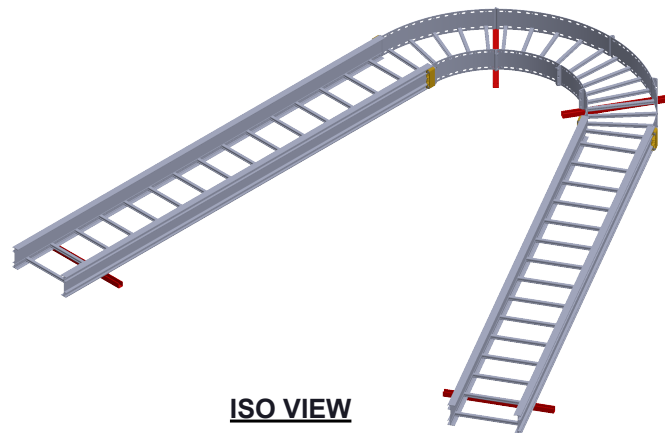
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 150° HORIZONTAL BEND SUPPORT



PLAN VIEW



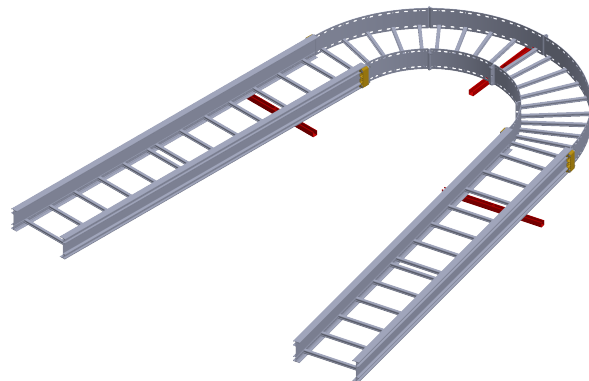
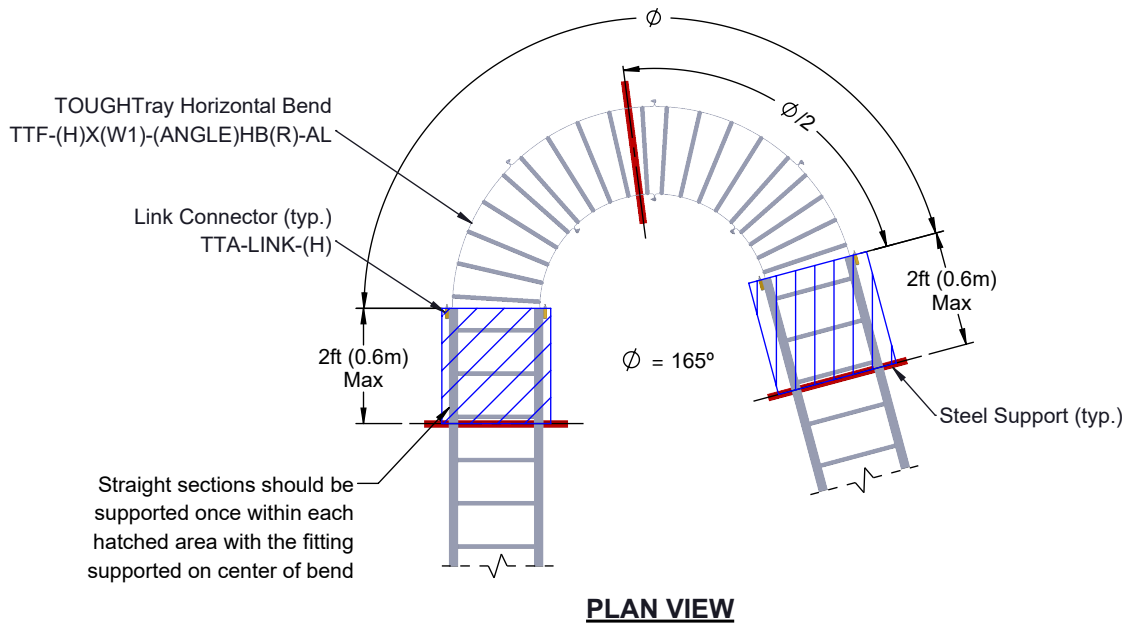
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 165° HORIZONTAL BEND SUPPORT

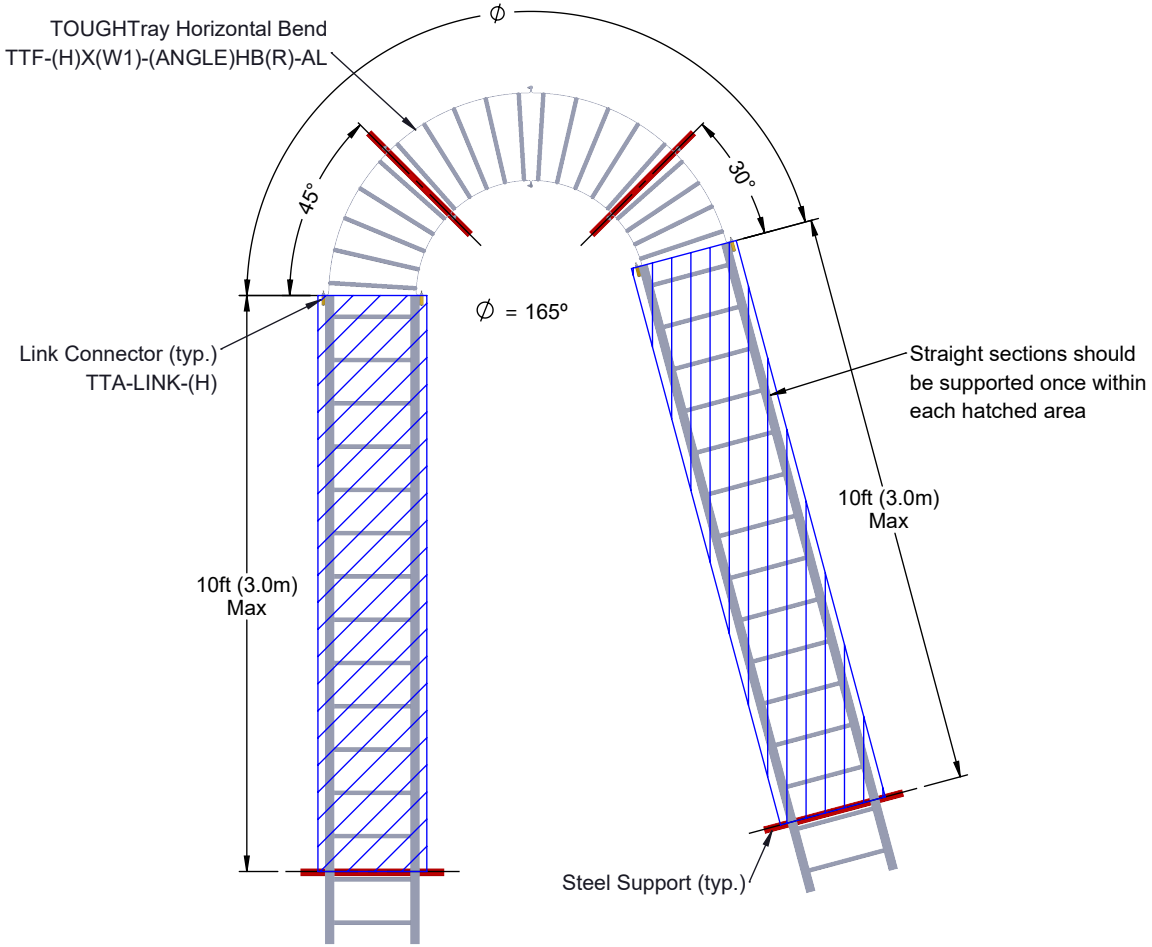


ISO VIEW

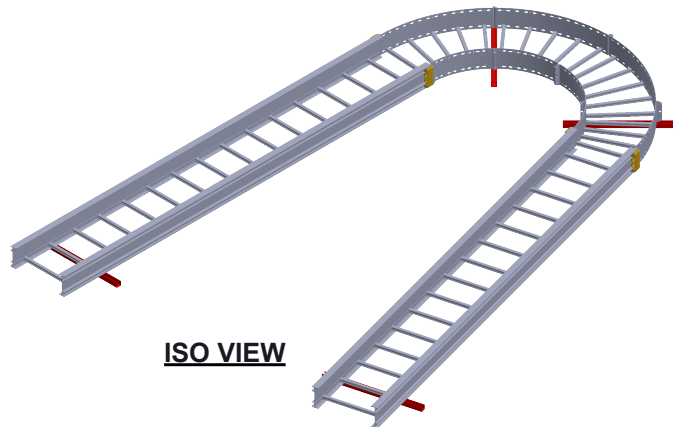
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 165° HORIZONTAL BEND SUPPORT



PLAN VIEW



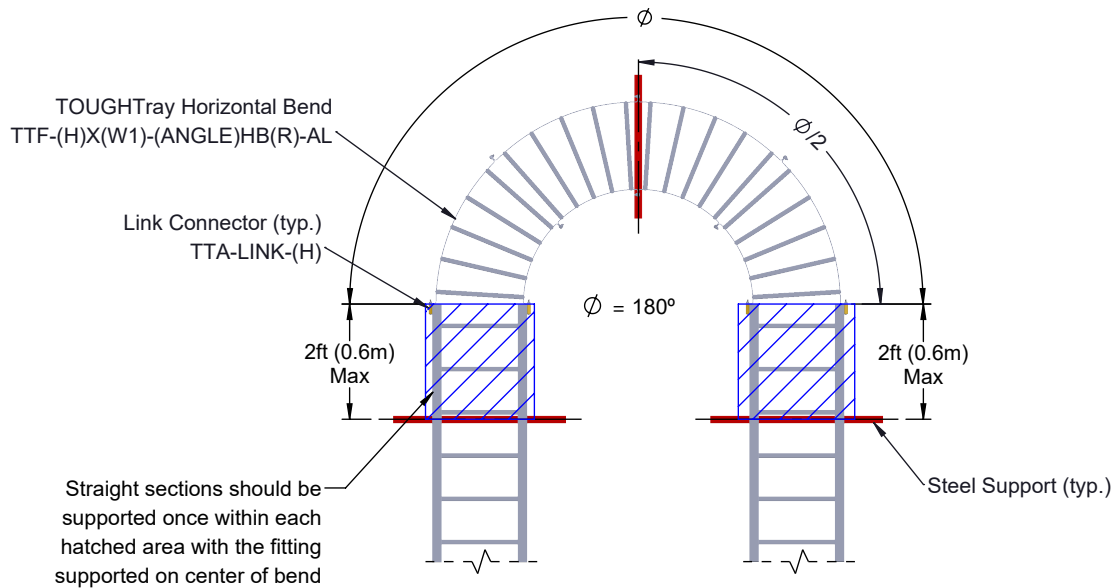
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

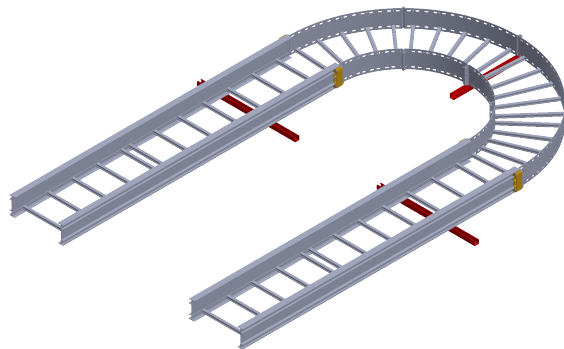
FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 180° HORIZONTAL BEND SUPPORT



PLAN VIEW

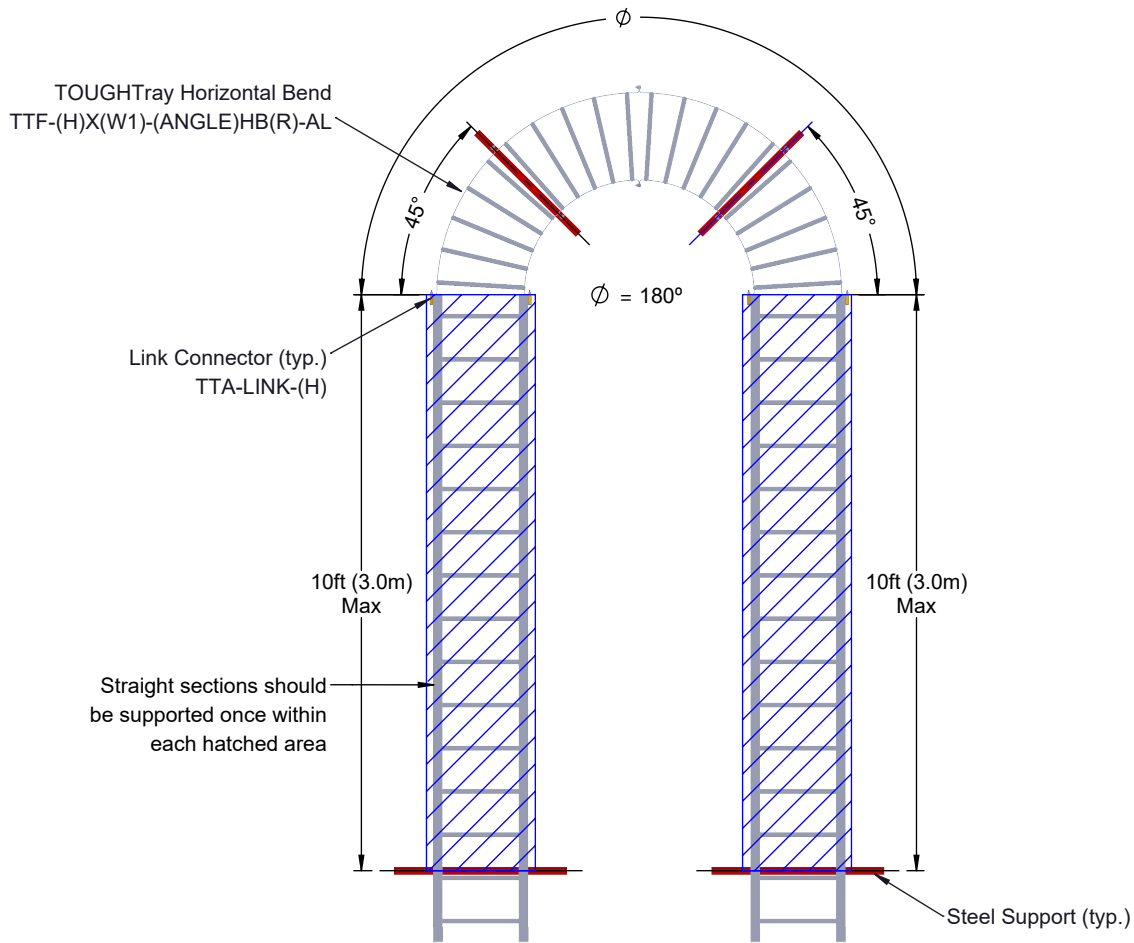


ISO VIEW

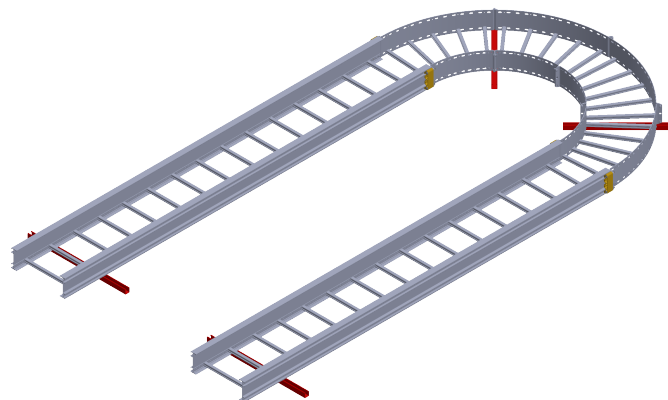
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray 180° HORIZONTAL BEND SUPPORT



PLAN VIEW



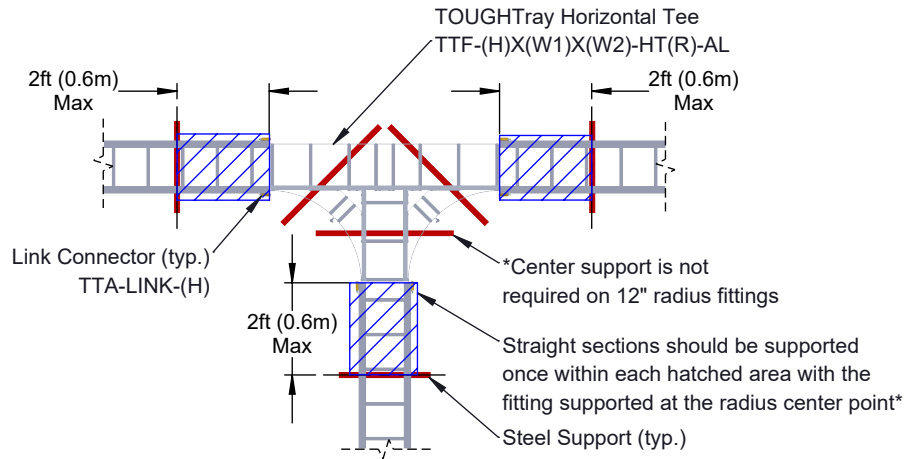
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

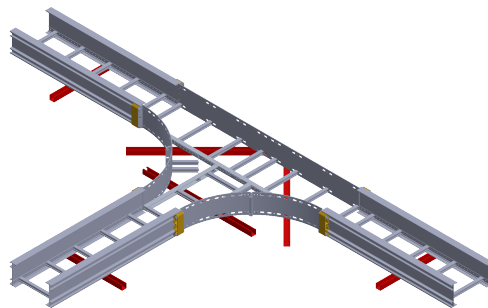
FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

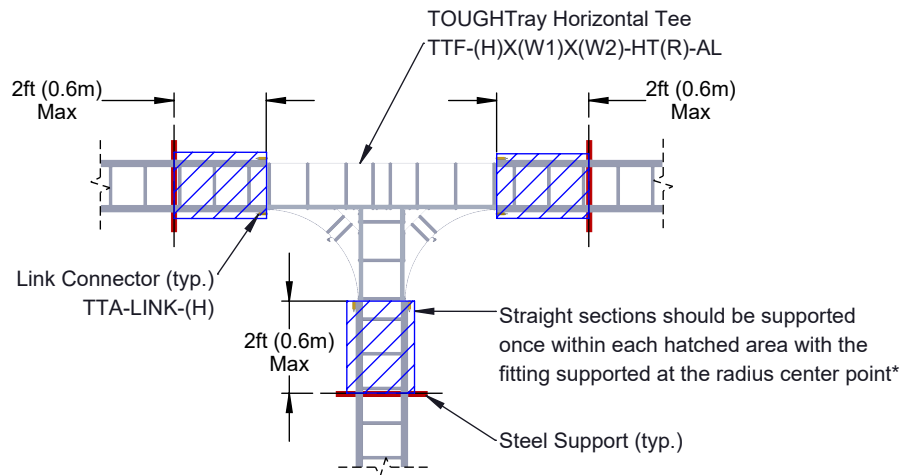


ISO VIEW

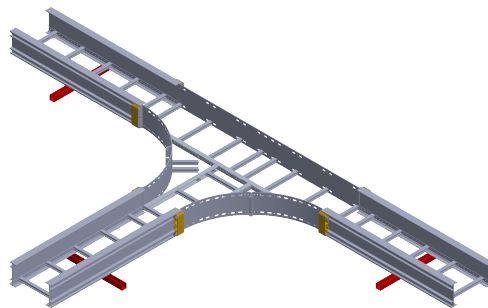
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

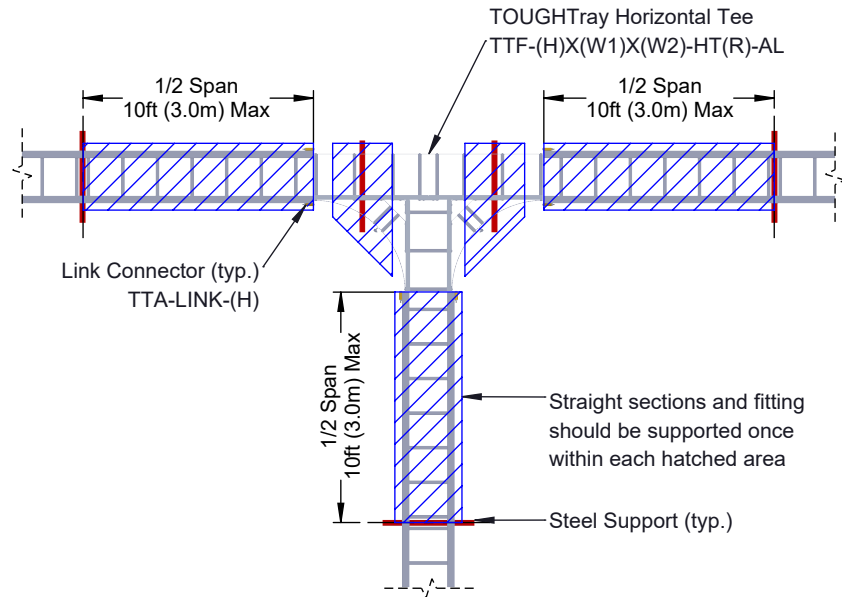


ISO VIEW

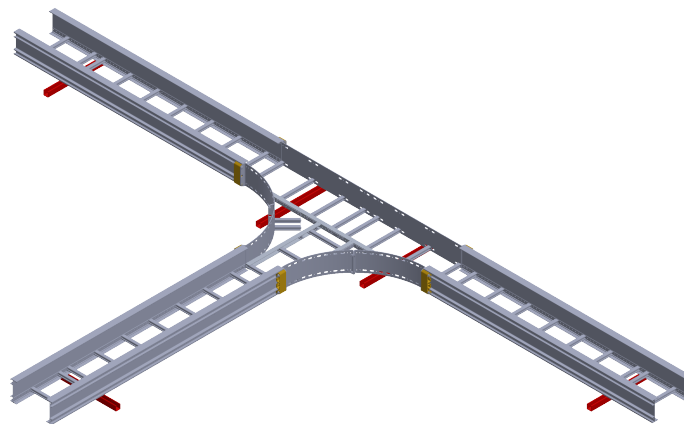
**FIGURE 2: TOUGH SUPPORT SAVINGS
"UNSUPPORTED FITTING"**



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

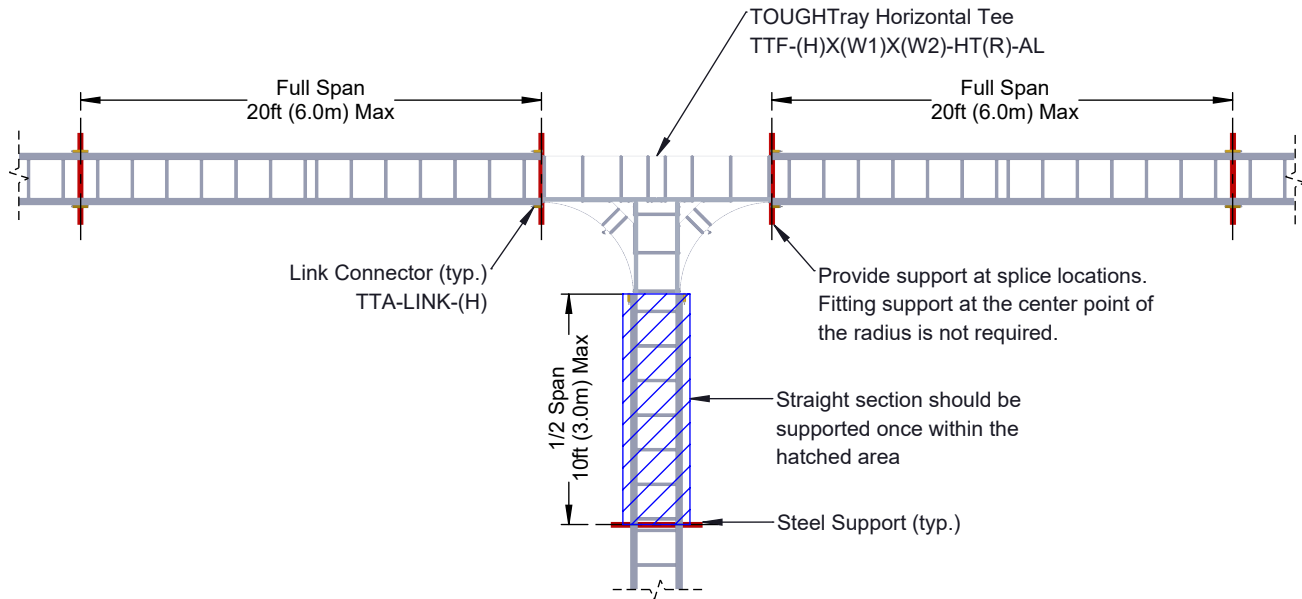


ISO VIEW

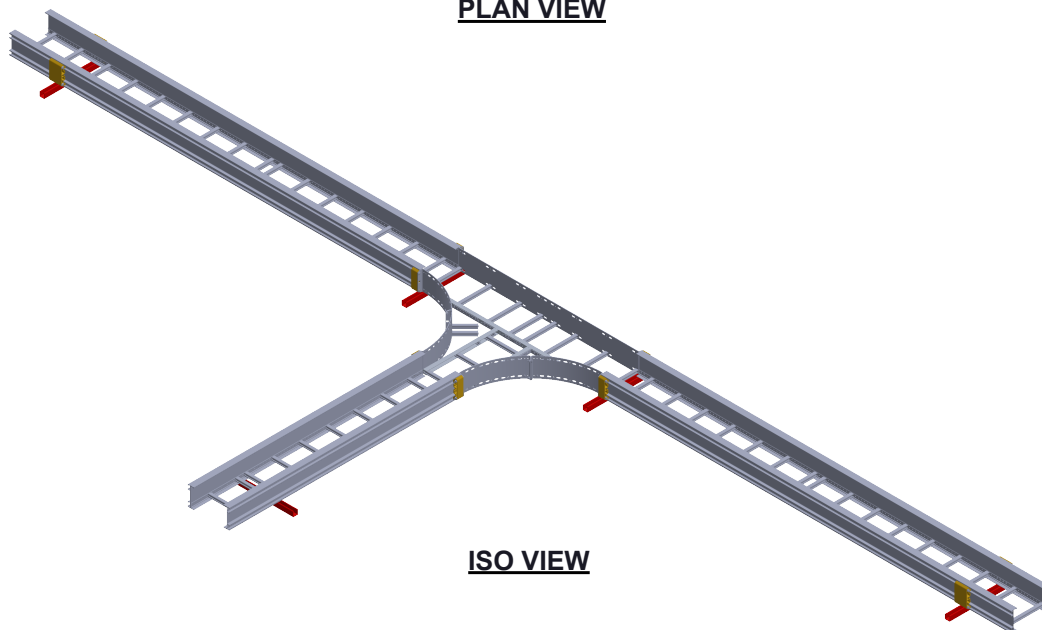
**FIGURE 3: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED"**



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

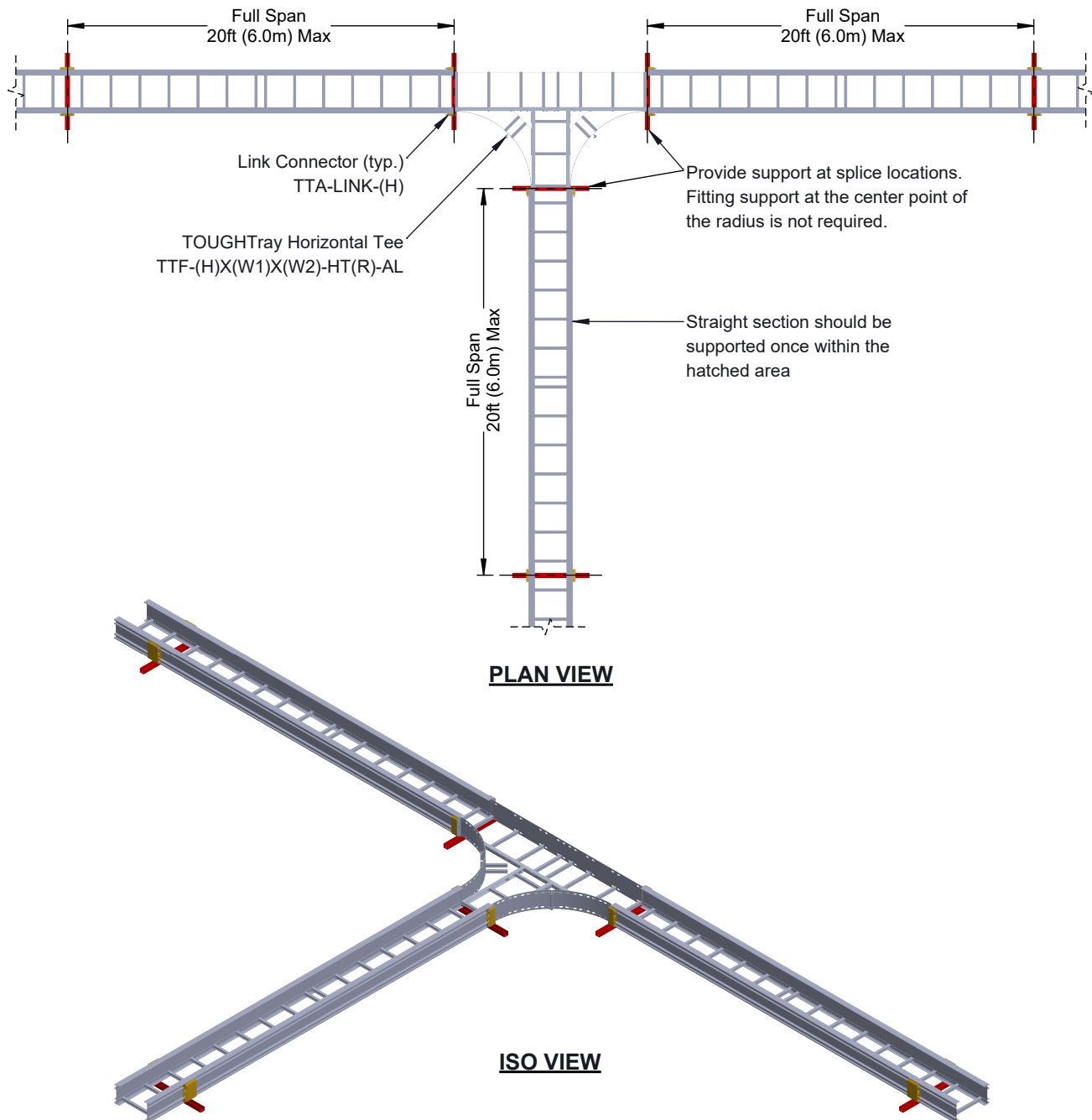


ISO VIEW

**FIGURE 4: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED + DUAL SUPPORT"**



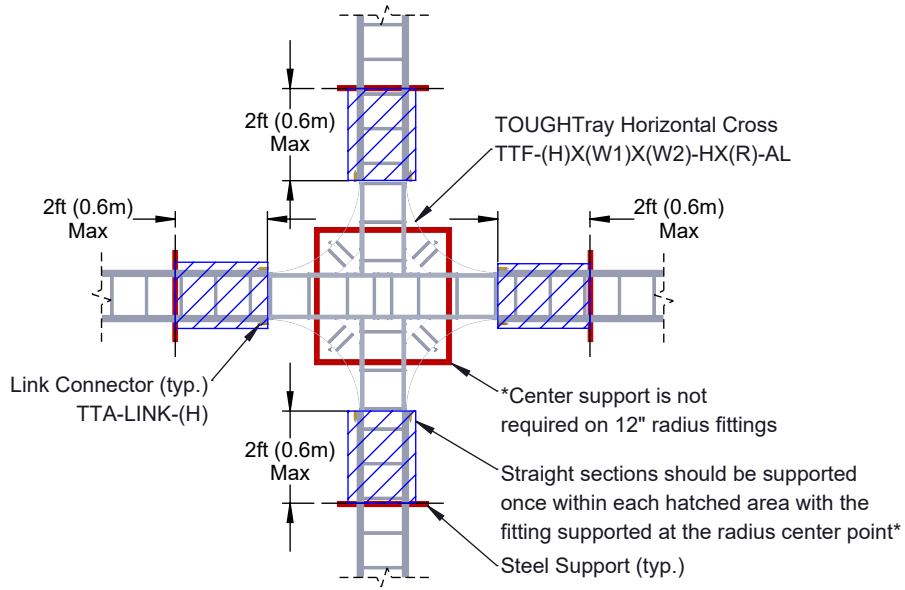
TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



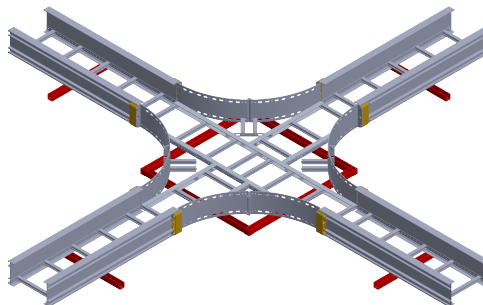
**FIGURE 5: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

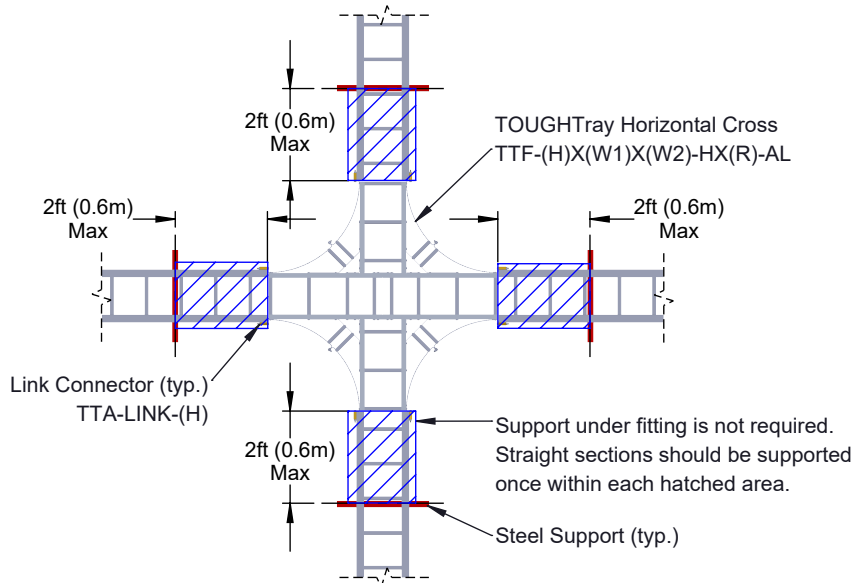


ISO VIEW

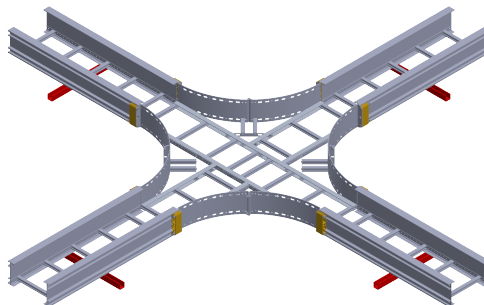
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

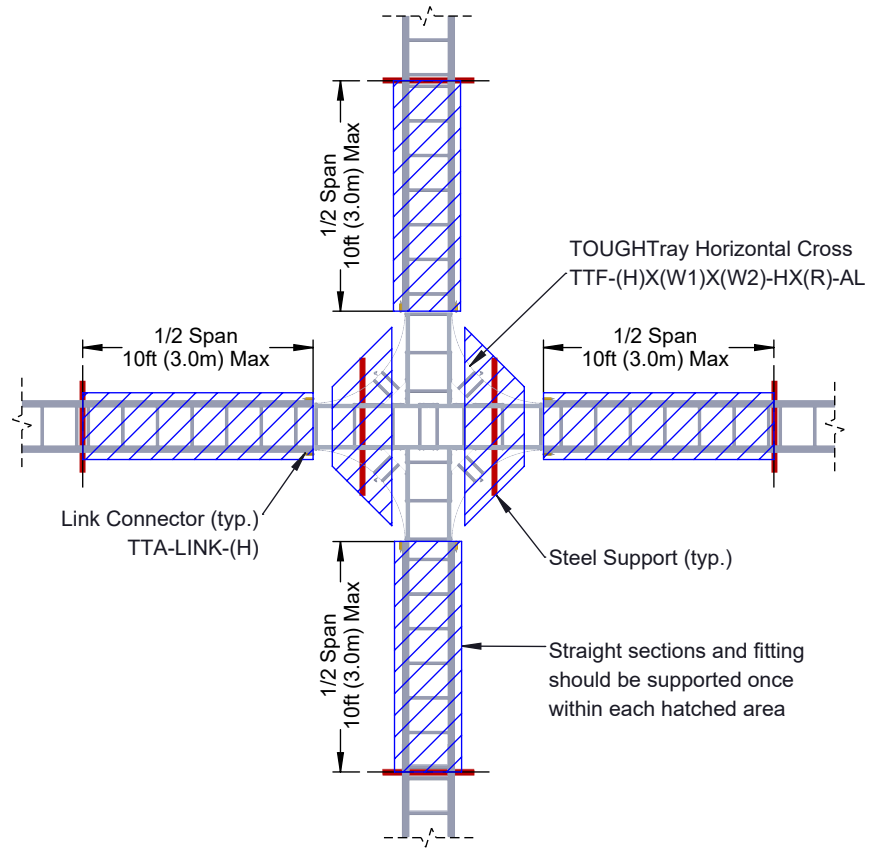


ISO VIEW

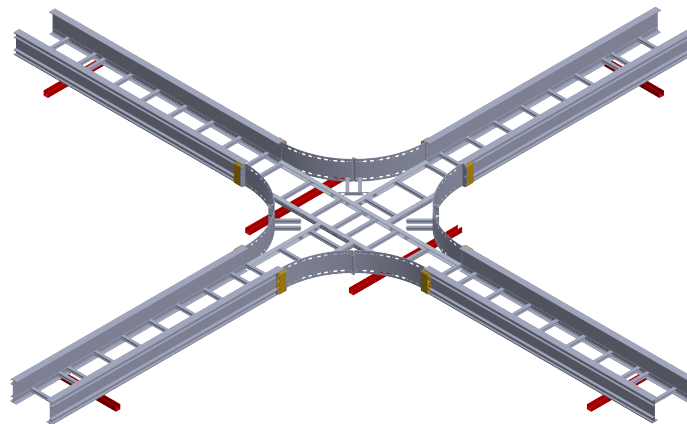
**FIGURE 2: TOUGH SUPPORT SAVINGS
"UNSUPPORTED FITTING"**



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW

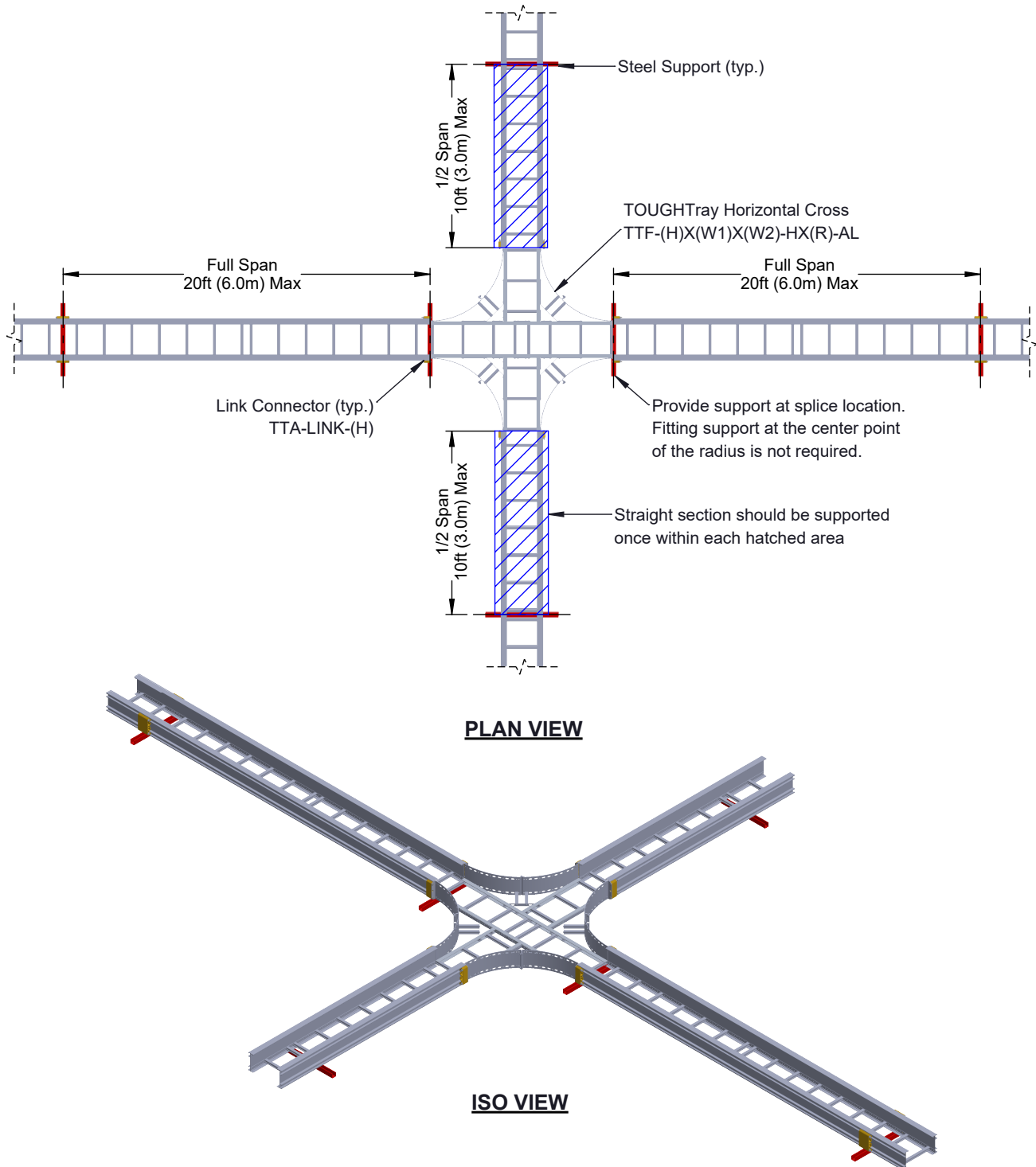


ISO VIEW

**FIGURE 3: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED"**



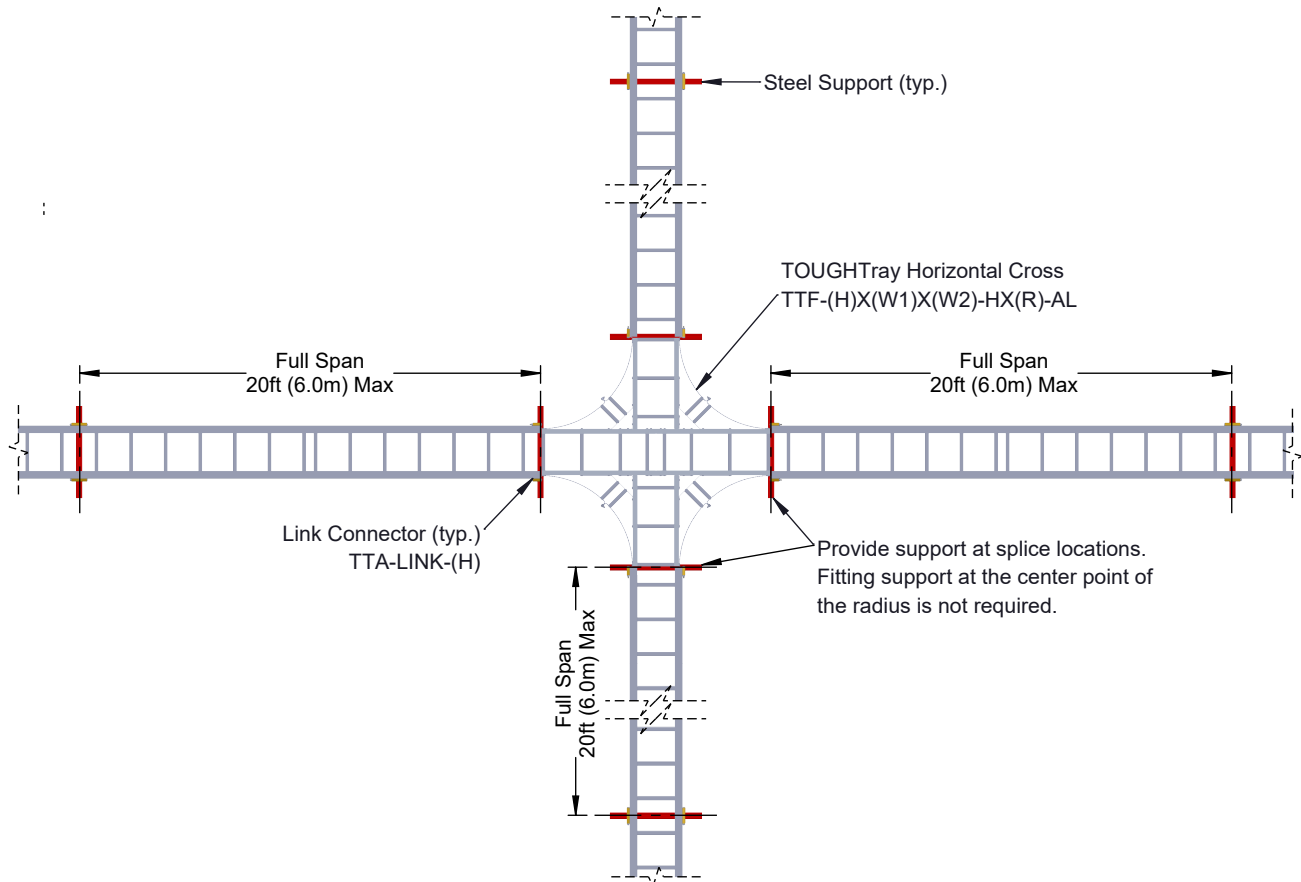
TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



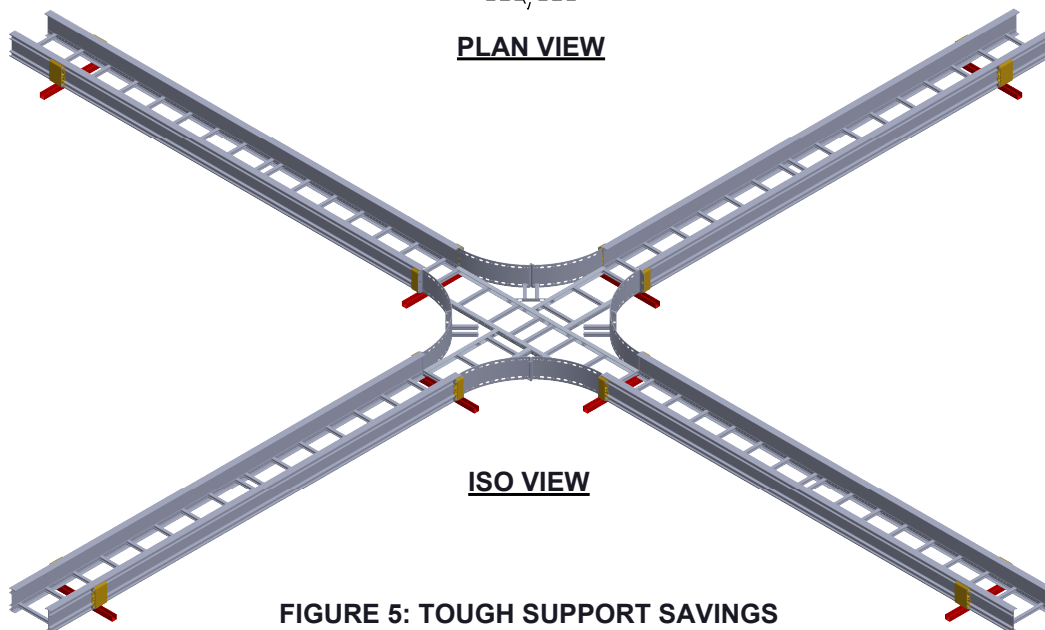
**FIGURE 4: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED + DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray Horizontal Tee



PLAN VIEW



ISO VIEW

**FIGURE 5: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray
Vertical Inside/Outside Bend

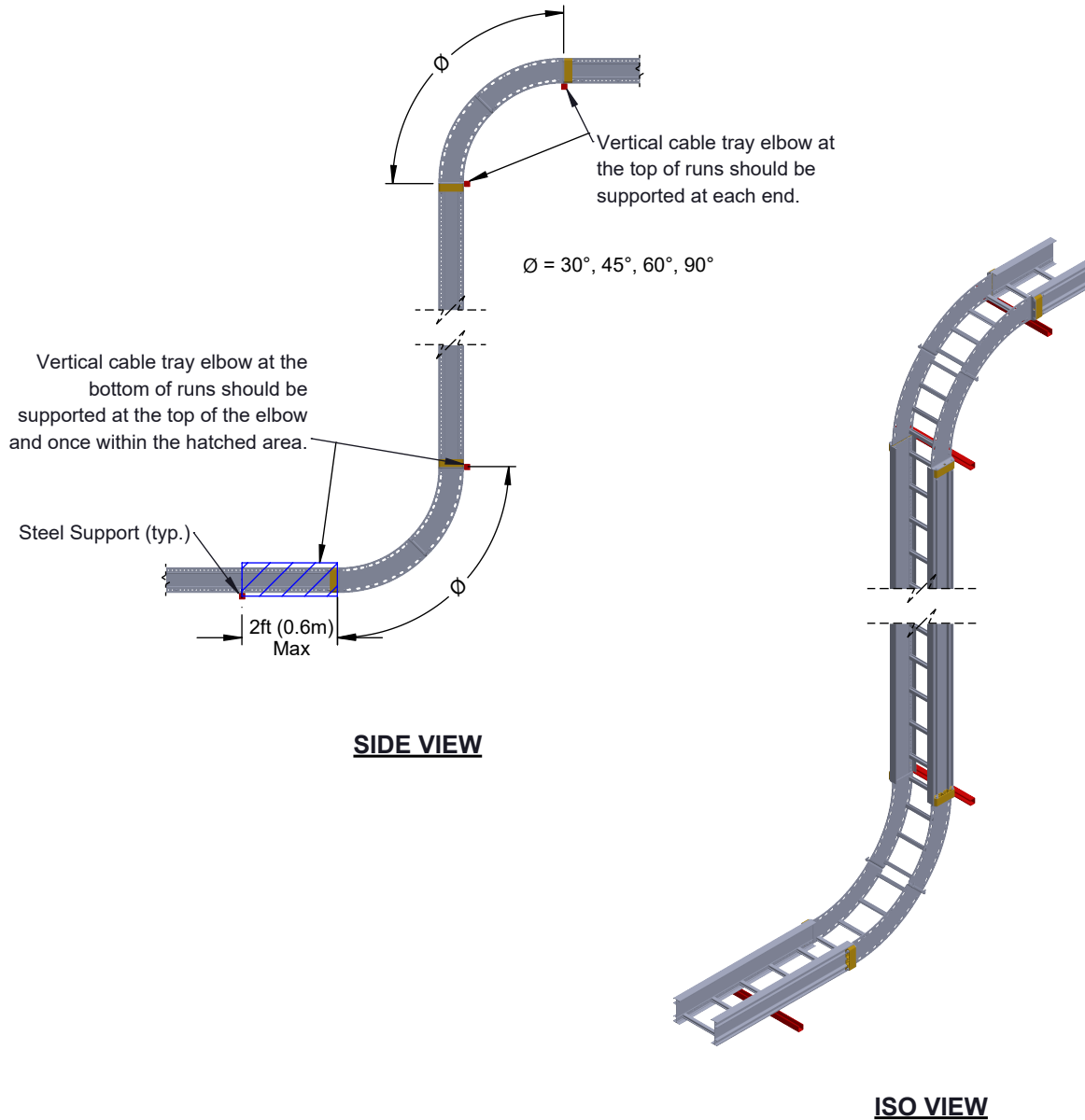
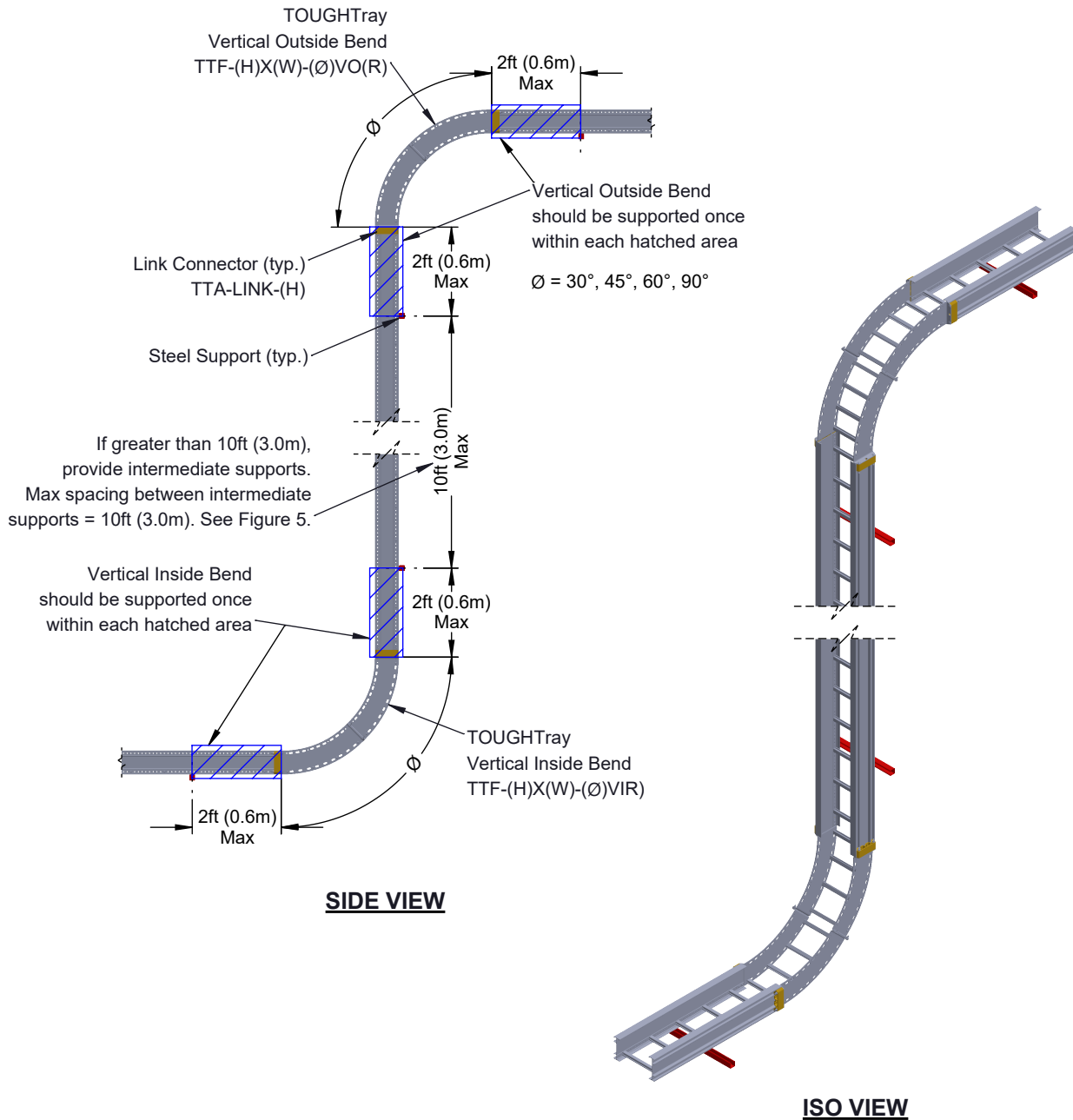


FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



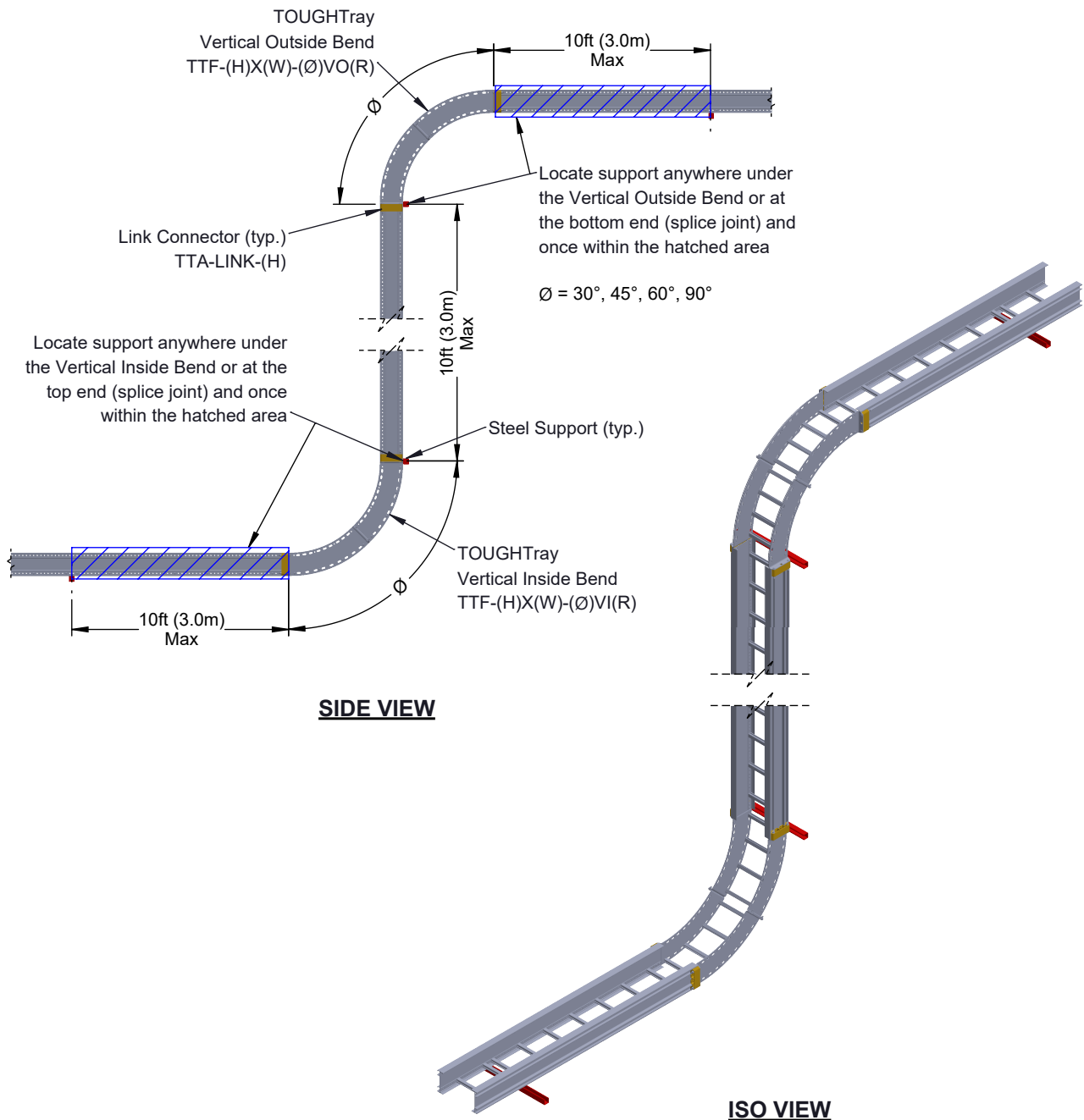
**TOUGH SUPPORT SAVINGS for TOUGHTray
Vertical Inside/Outside Bend**



**FIGURE 2: TOUGH SUPPORT SAVINGS
"UNSUPPORTED FITTING"**



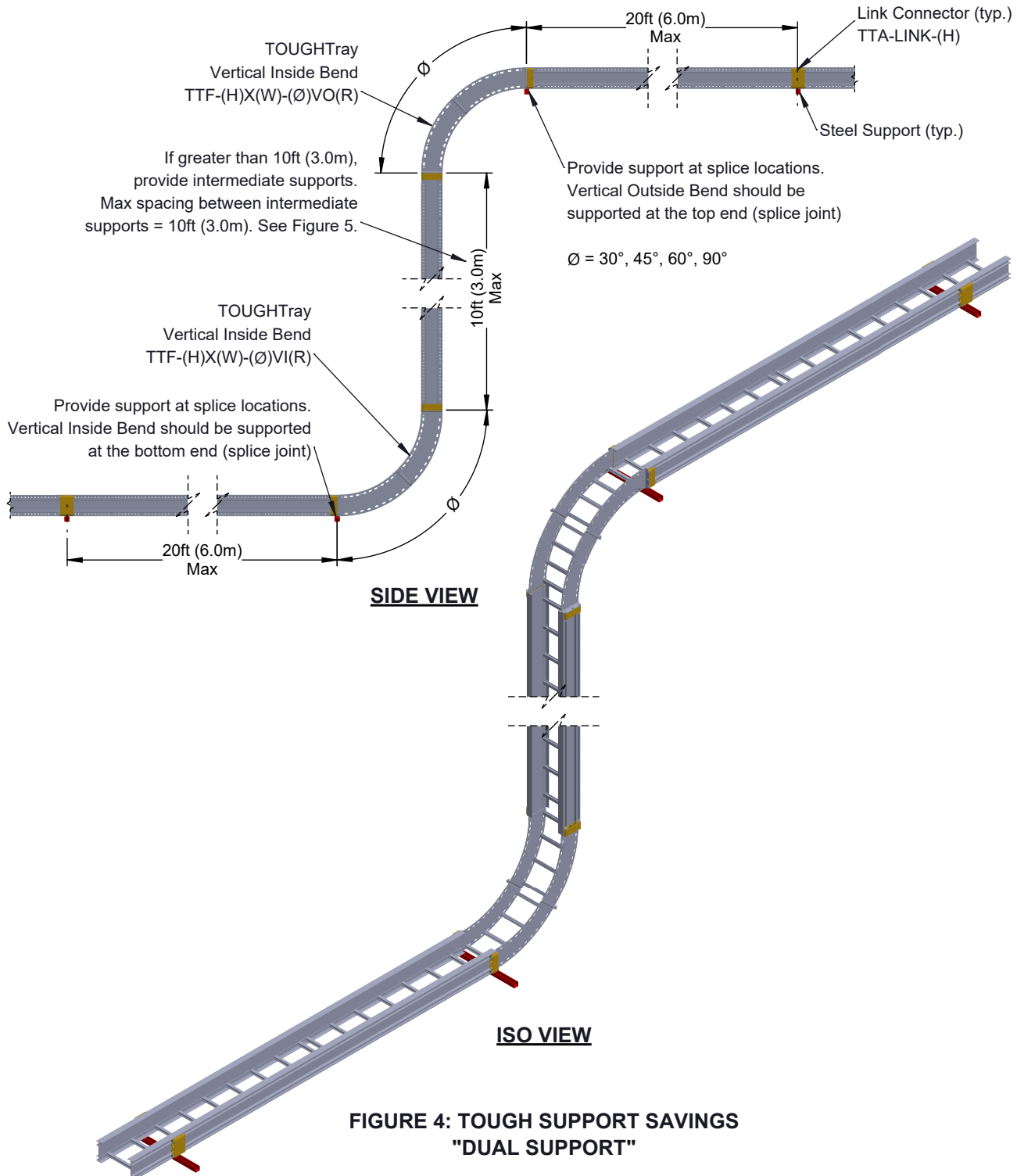
**TOUGH SUPPORT SAVINGS for TOUGHTray
Vertical Inside/Outside Bend**



**FIGURE 3: TOUGH SUPPORT SAVINGS
"1/2 SPAN EXTENDED"**



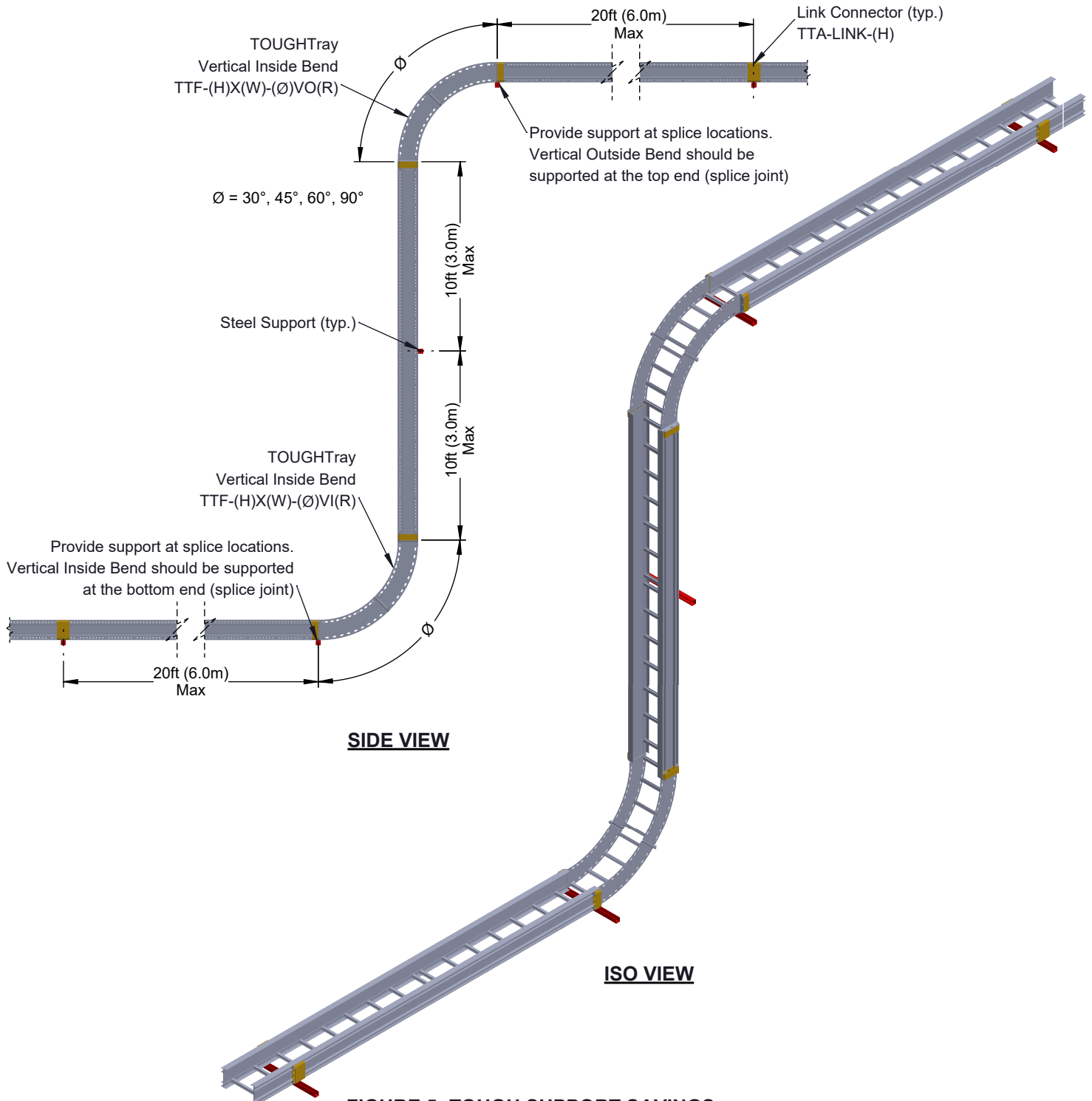
TOUGH SUPPORT SAVINGS for TOUGHTray Vertical Inside/Outside Bend



**FIGURE 4: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



TOUGH SUPPORT SAVINGS for TOUGHTray Vertical Inside/Outside Bend



**FIGURE 5: TOUGH SUPPORT SAVINGS
"DUAL SUPPORT"**



**TOUGH SUPPORT SAVINGS for TOUGHTray 105°/120°/135°
VERTICAL INSIDE/OUTSIDE BEND**

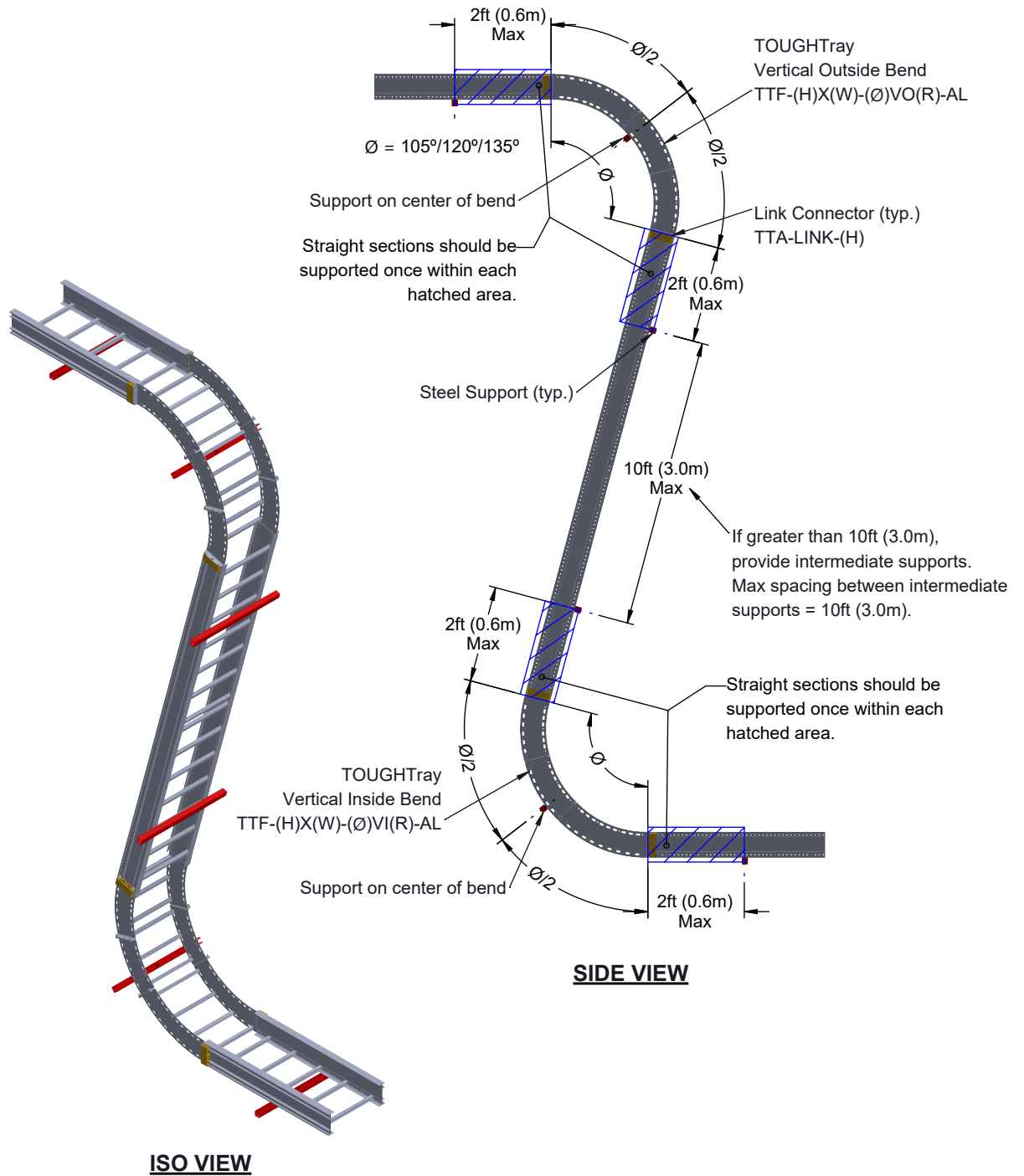
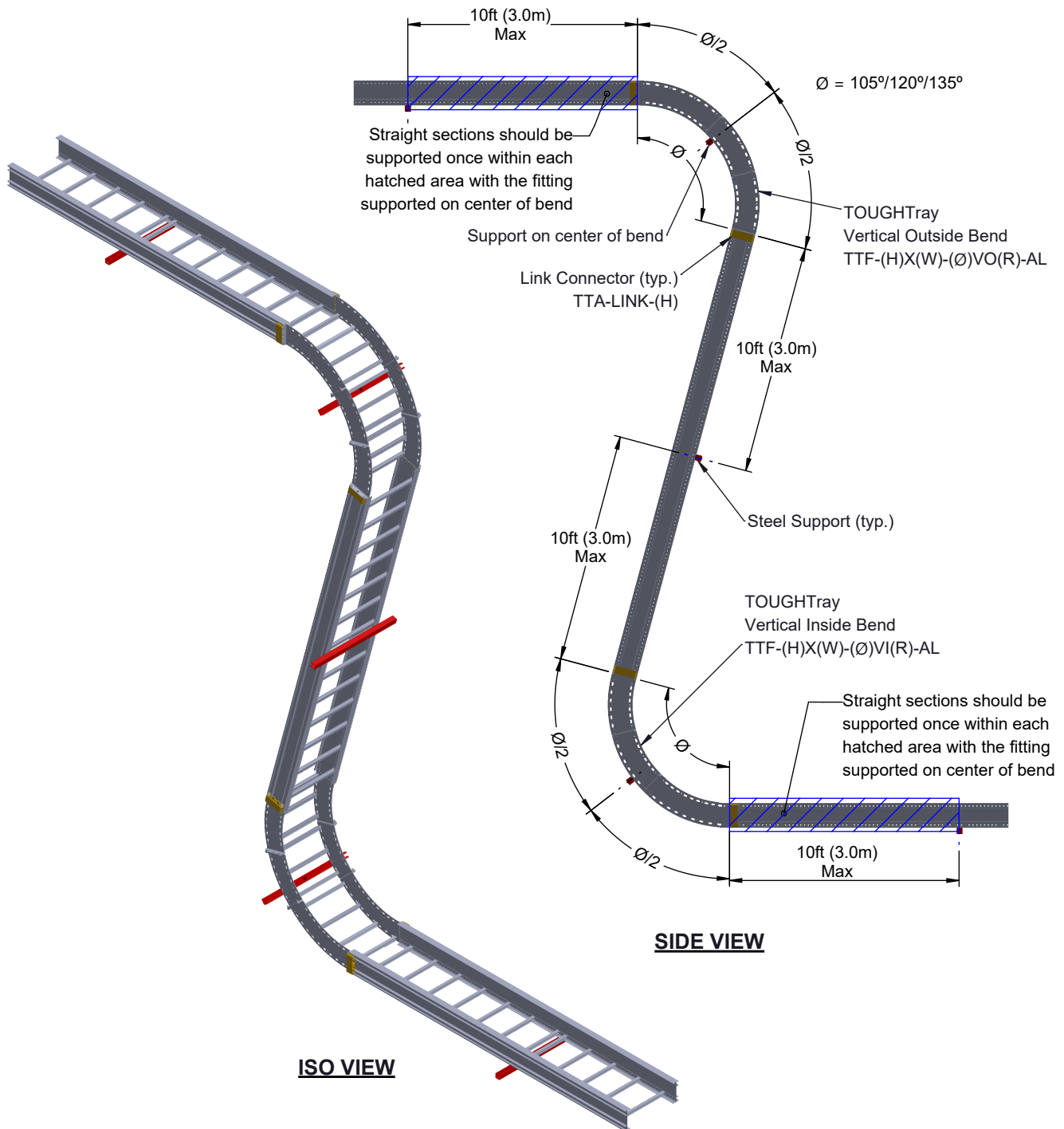


FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray 105°/120°/135°
VERTICAL INSIDE/OUTSIDE BEND**



SIDE VIEW

ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
150° VERTICAL INSIDE/OUTSIDE BEND**

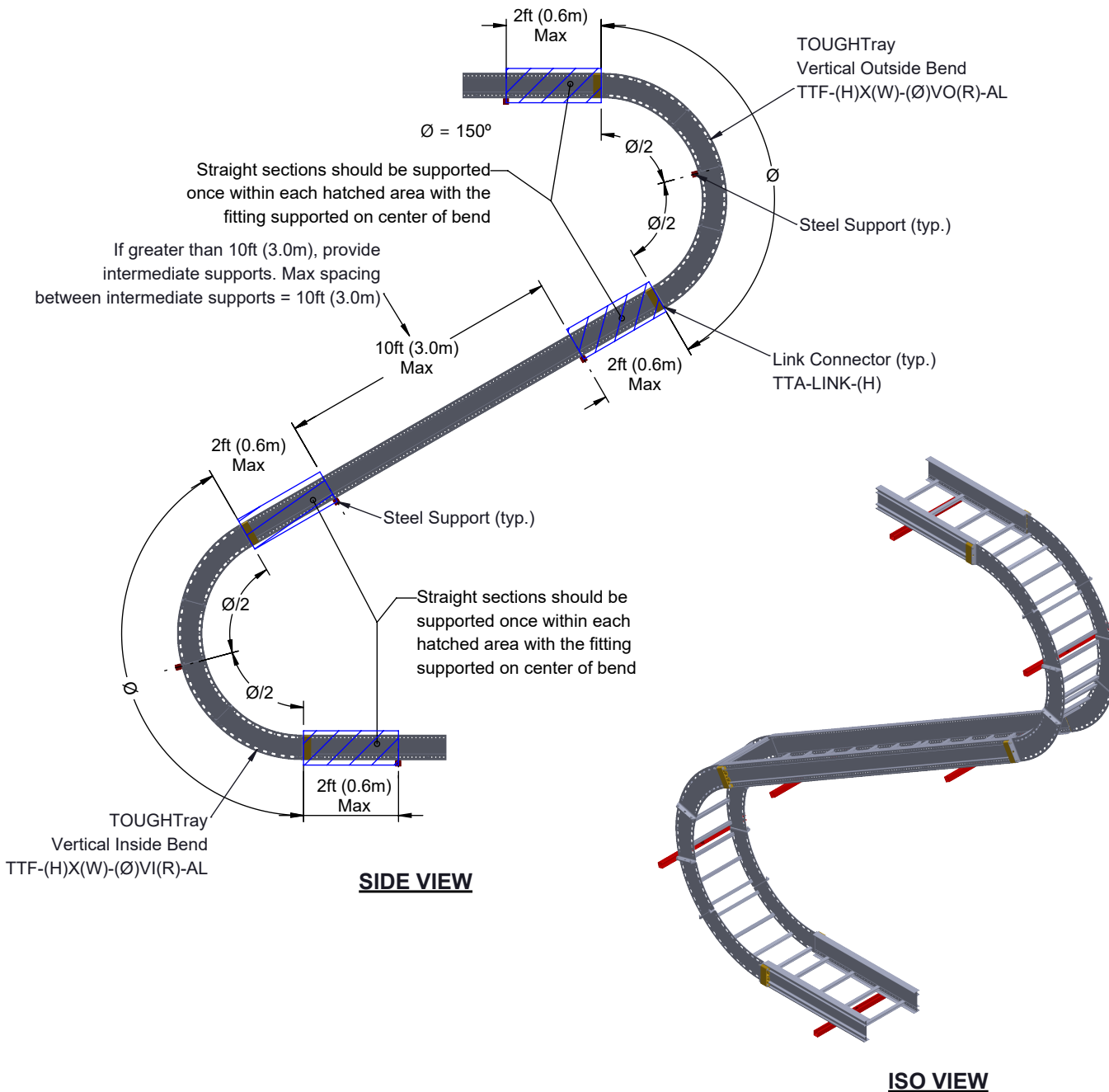
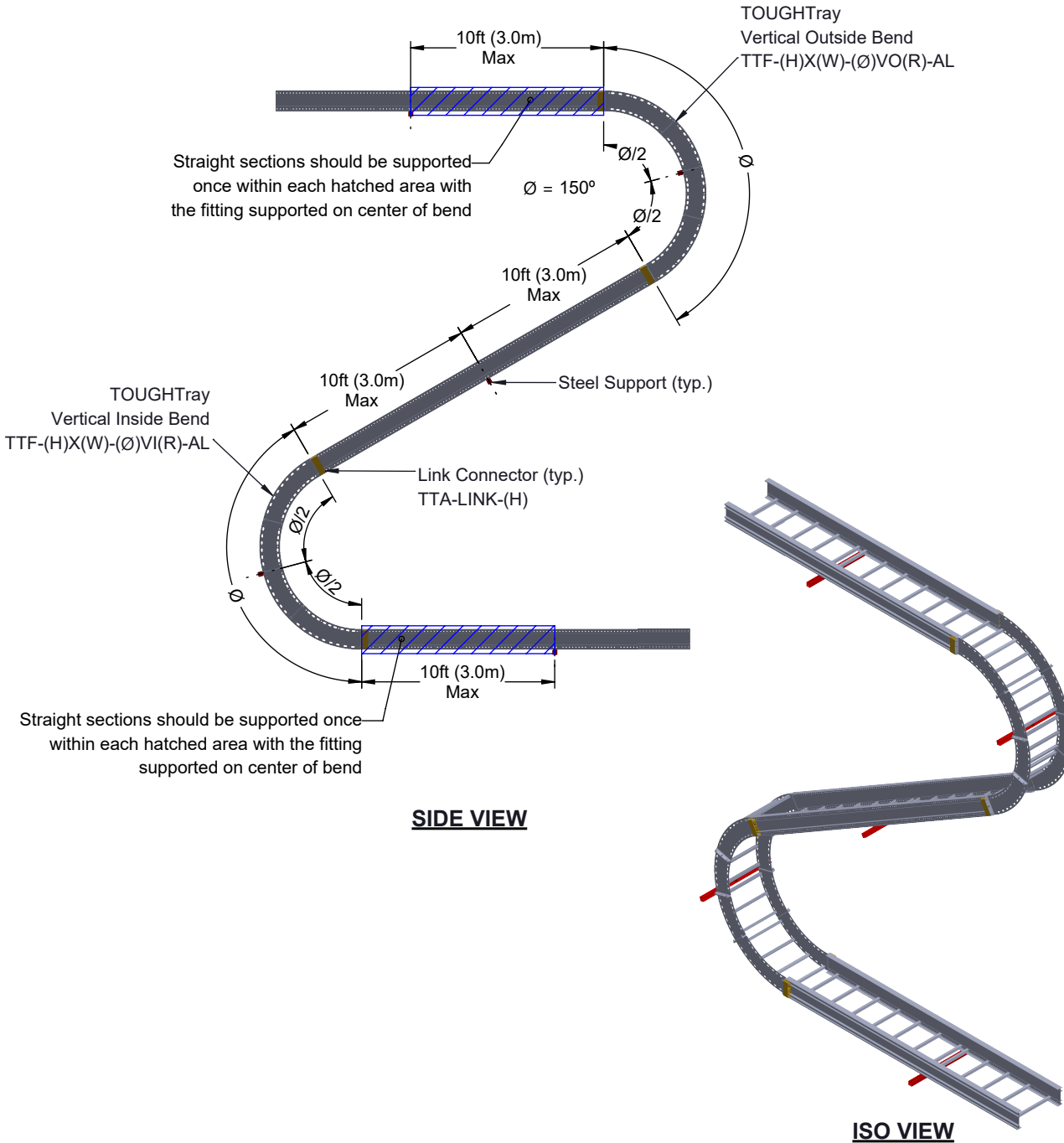


FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
150° VERTICAL INSIDE/OUTSIDE BEND**



PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
165° VERTICAL INSIDE/OUTSIDE BEND**

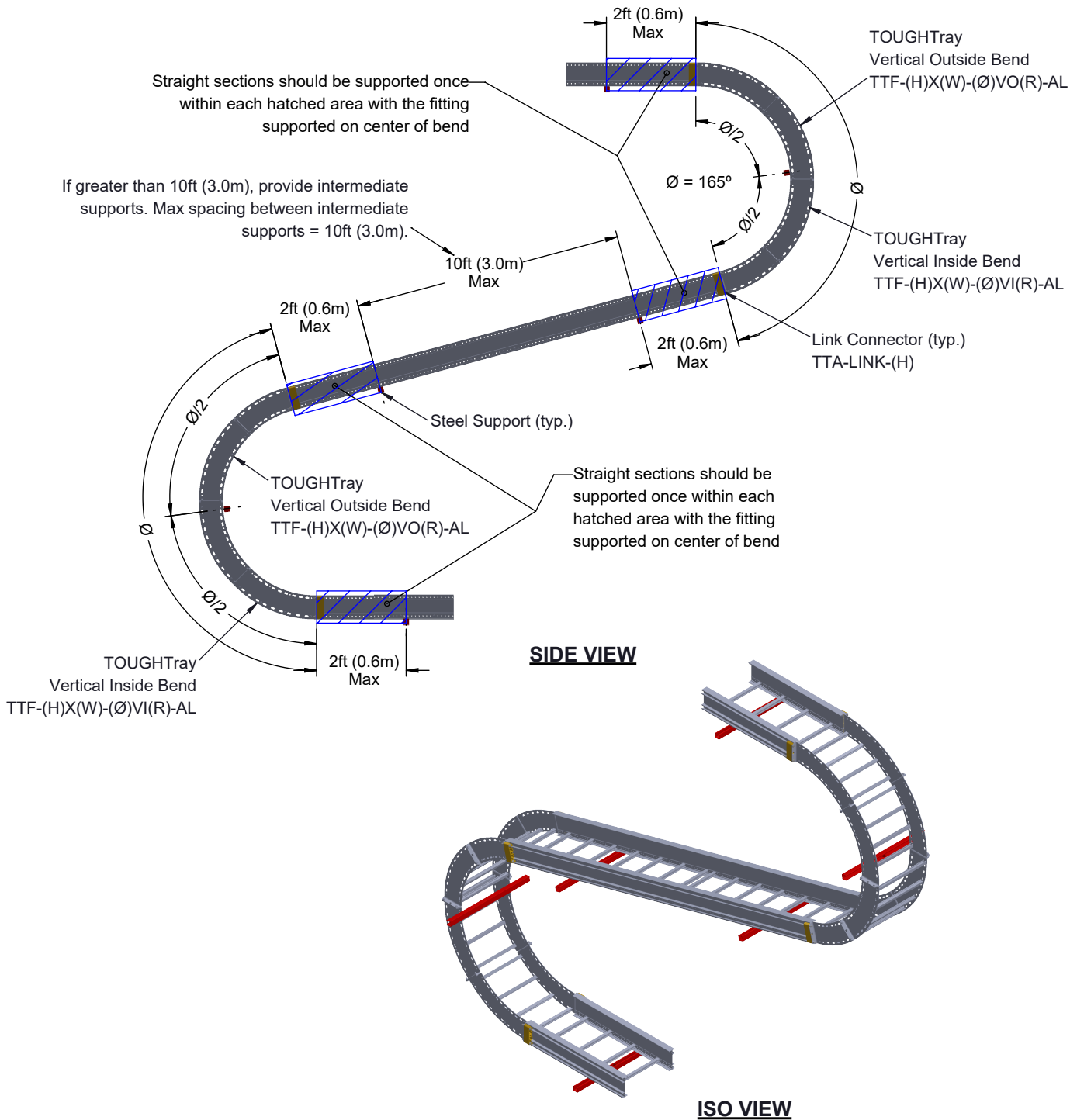
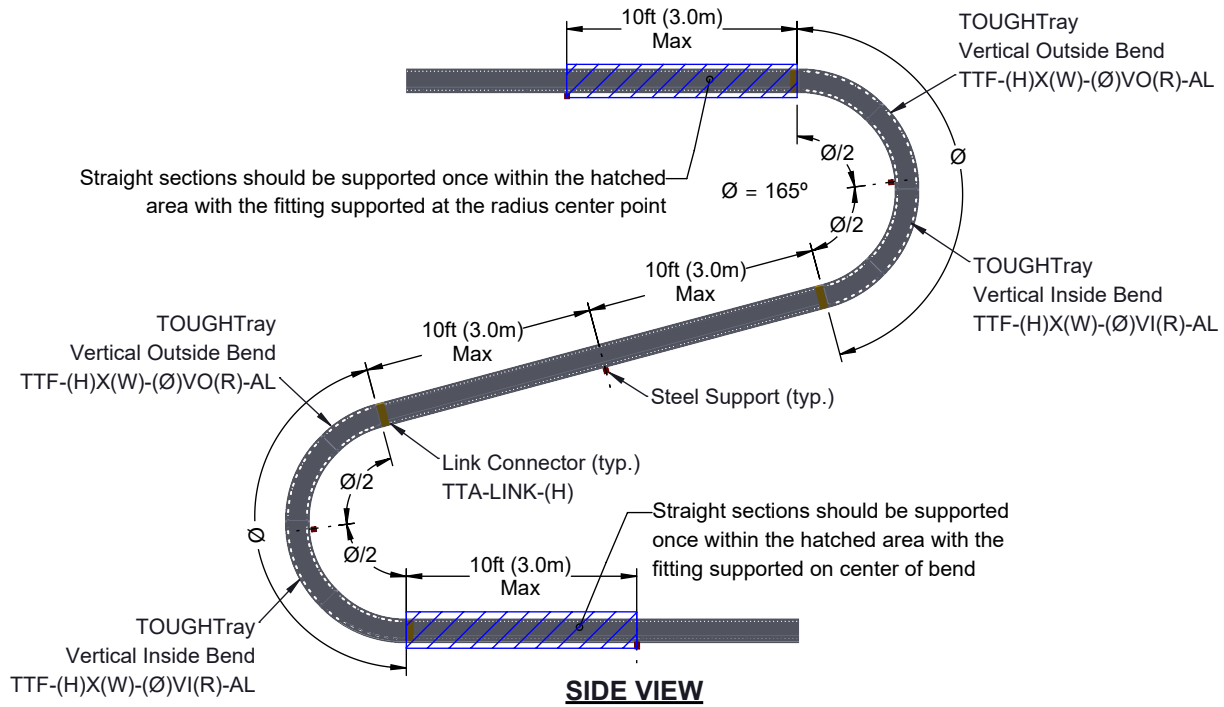


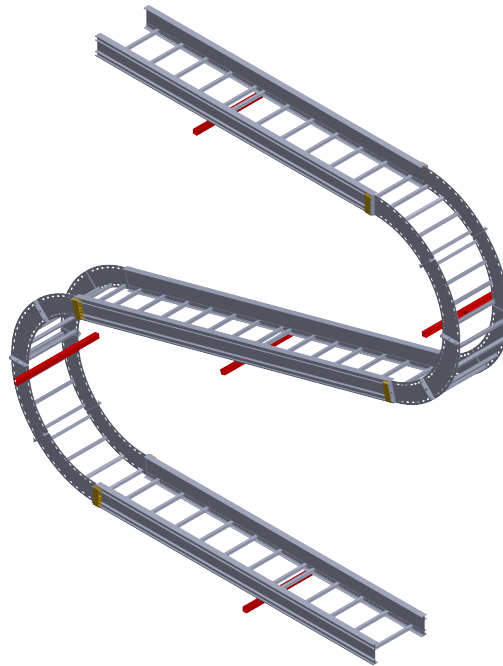
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
165° VERTICAL INSIDE/OUTSIDE BEND**



SIDE VIEW



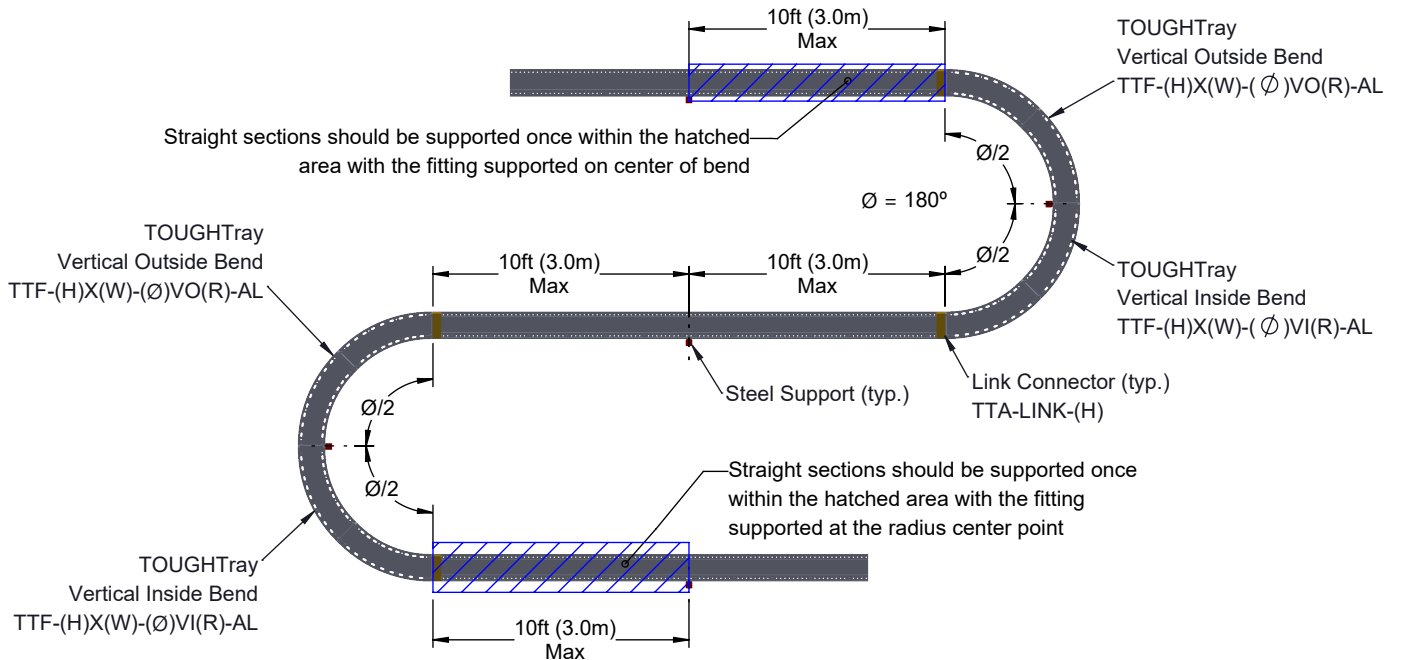
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

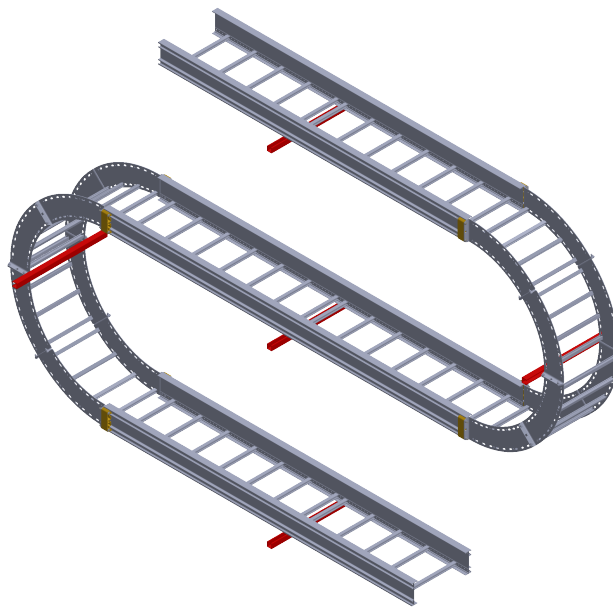
FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
180° VERTICAL INSIDE/OUTSIDE BEND**



SIDE VIEW



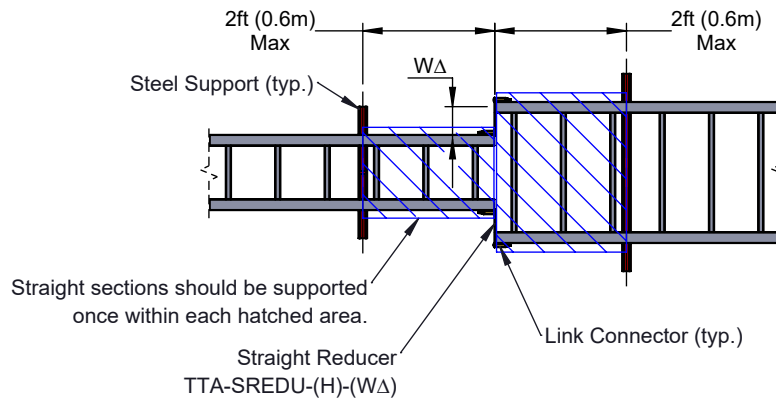
ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

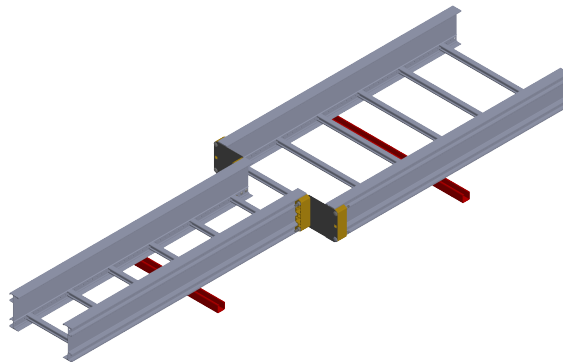
FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
Straight, Right, and Left Offset Reducers**



PLAN VIEW

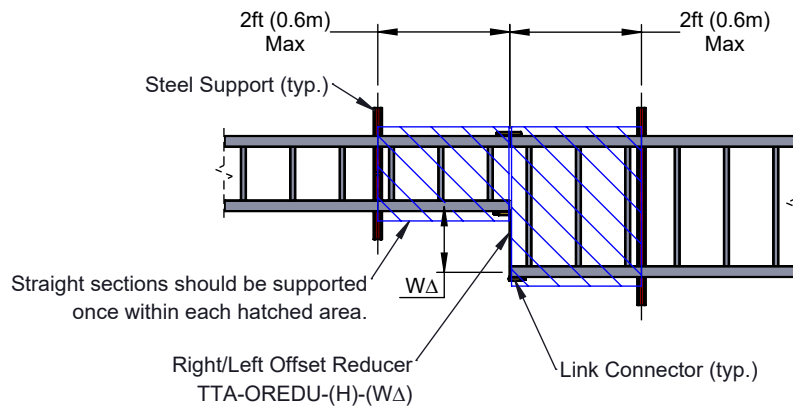


ISO VIEW

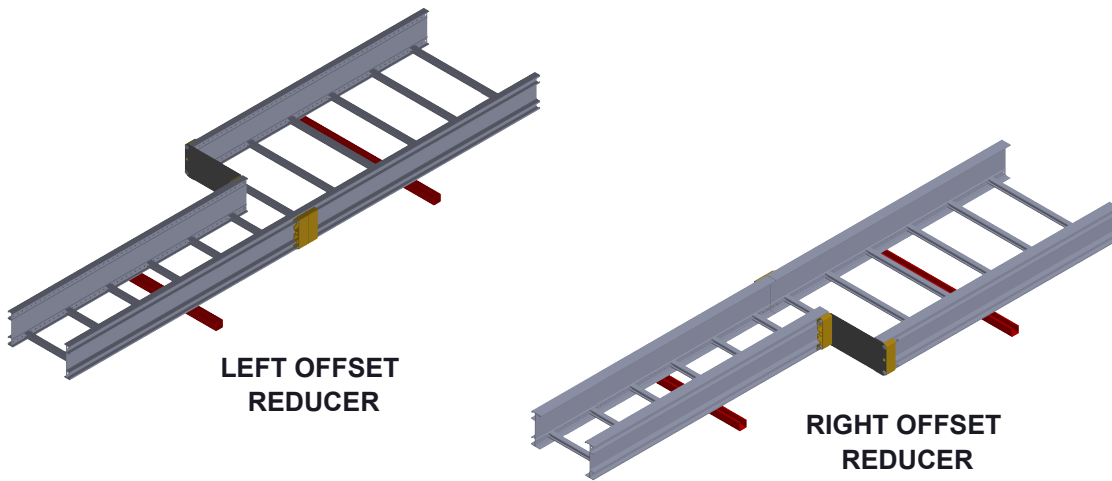
**FIGURE 1A: STRAIGHT REDUCER
NEMA VE-2 SUPPORT RECOMMENDATION**



**TOUGH SUPPORT SAVINGS for TOUGHTray
Straight, Right, and Left Offset Reducers**



PLAN VIEW



ISO VIEW

**FIGURE 2A: RIGHT/LEFT OFFSET REDUCER
NEMA VE-2 SUPPORT RECOMMENDATION**



TOUGH SUPPORT SAVINGS for TOUGHTray Vertical Adjustable Splice Plates

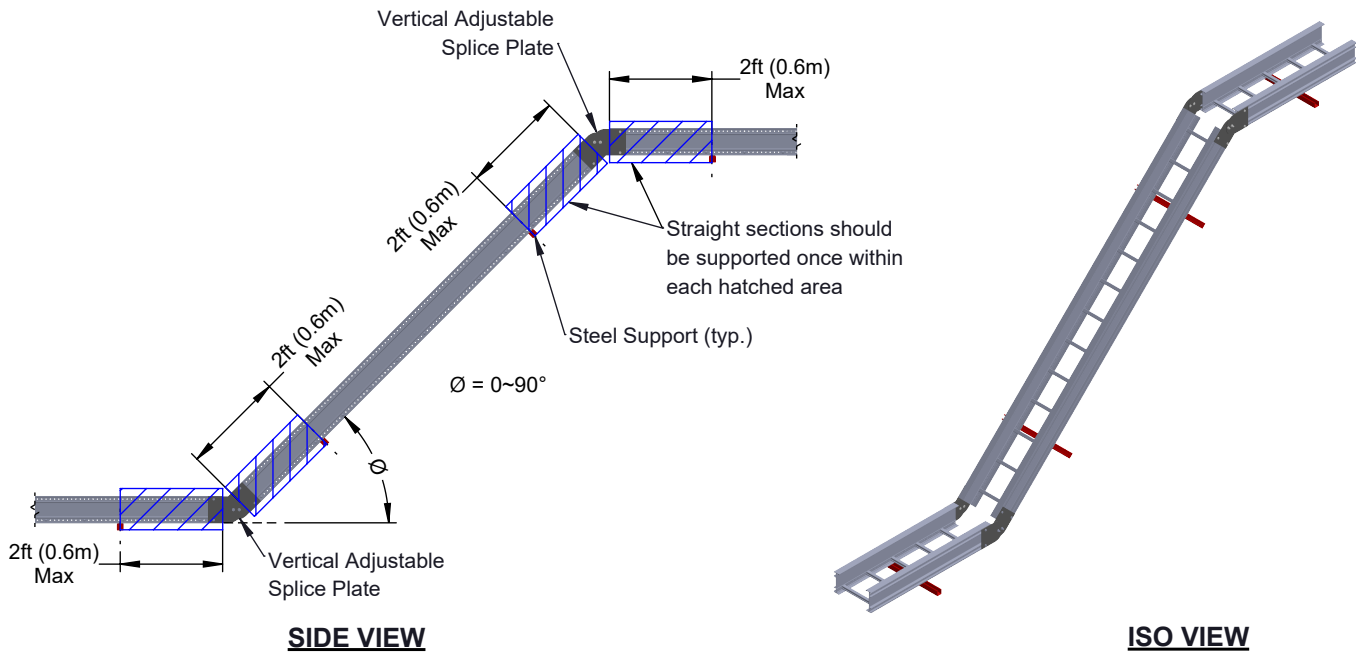


FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION

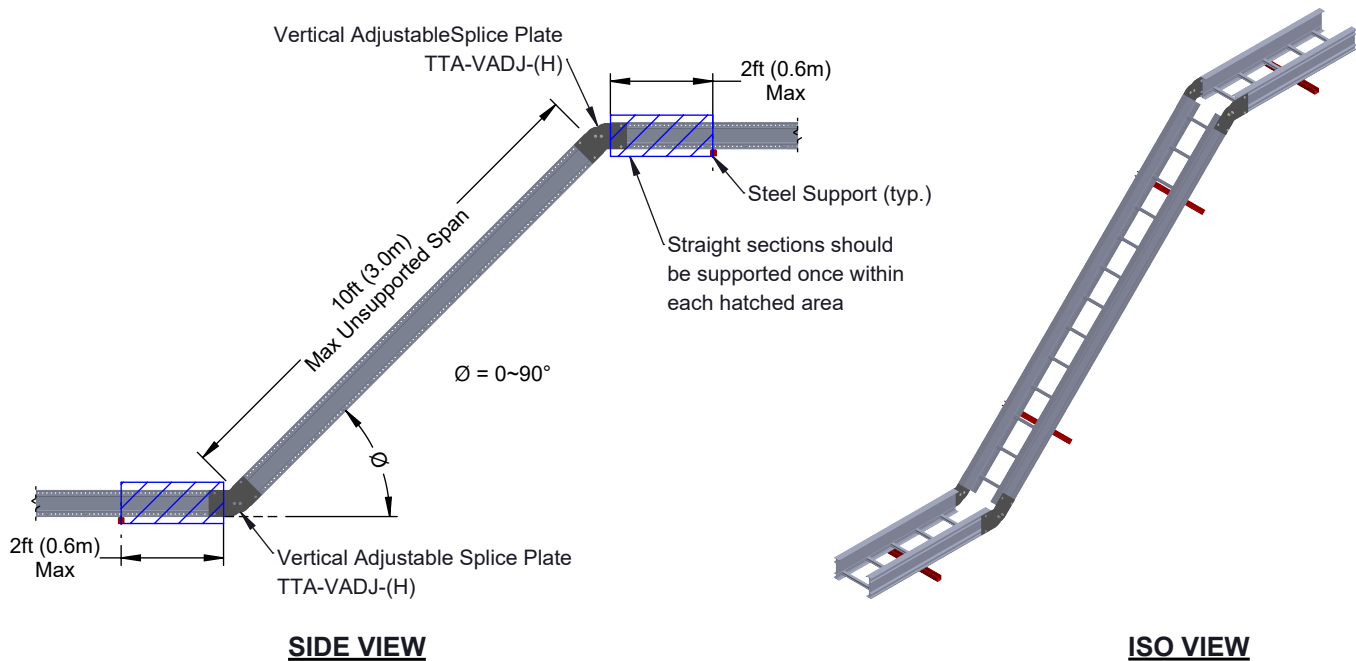
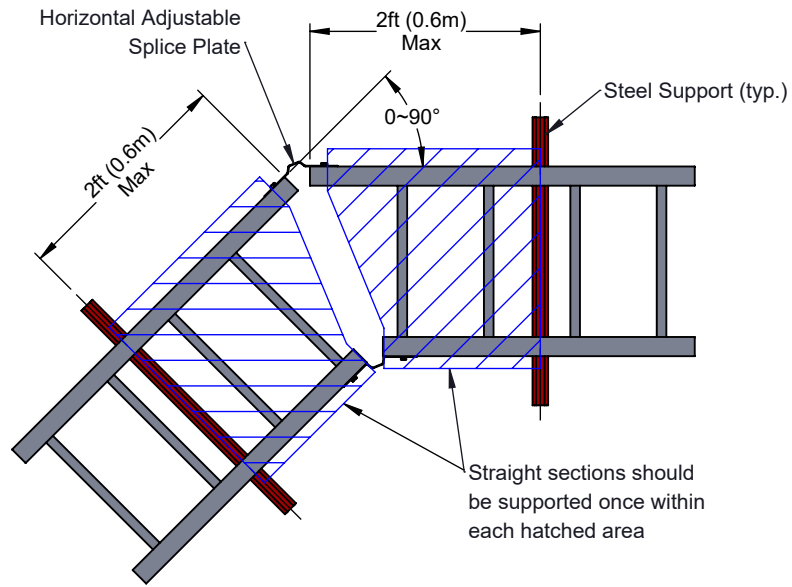


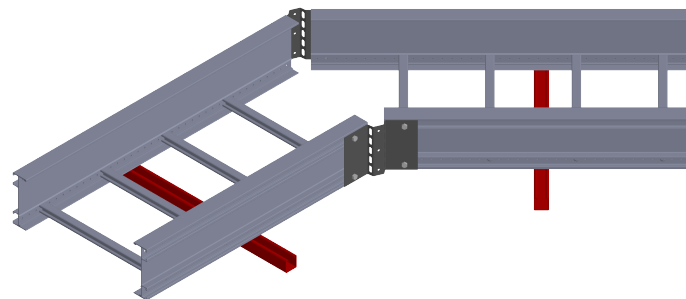
FIGURE 2: TOUGH SUPPORT SAVINGS



TOUGH SUPPORT for TOUGHTray Horizontal Adjustable Splice Plates



PLAN VIEW

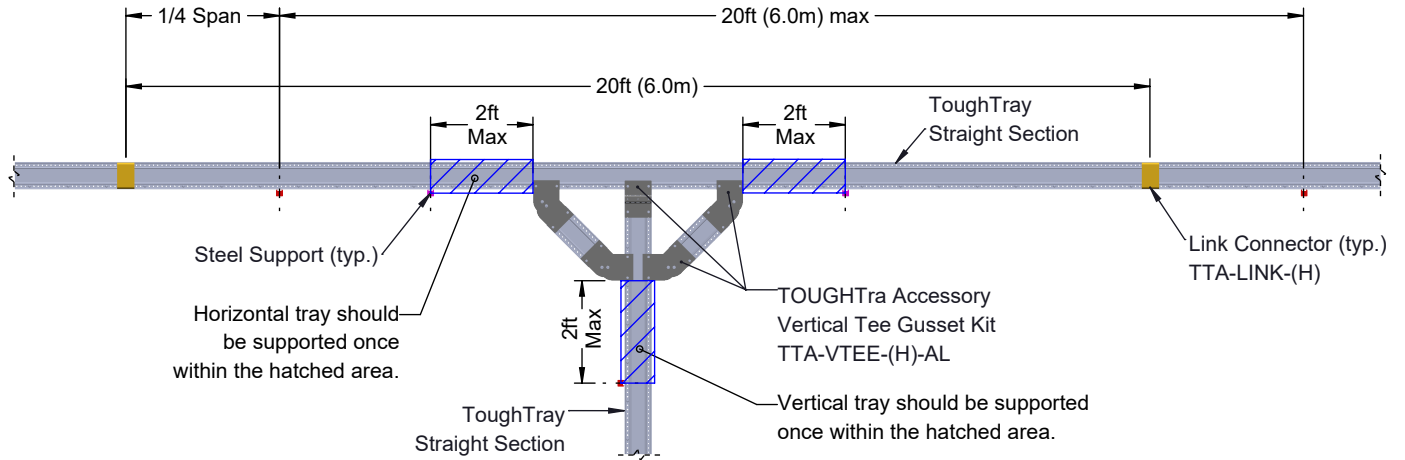


ISO VIEW

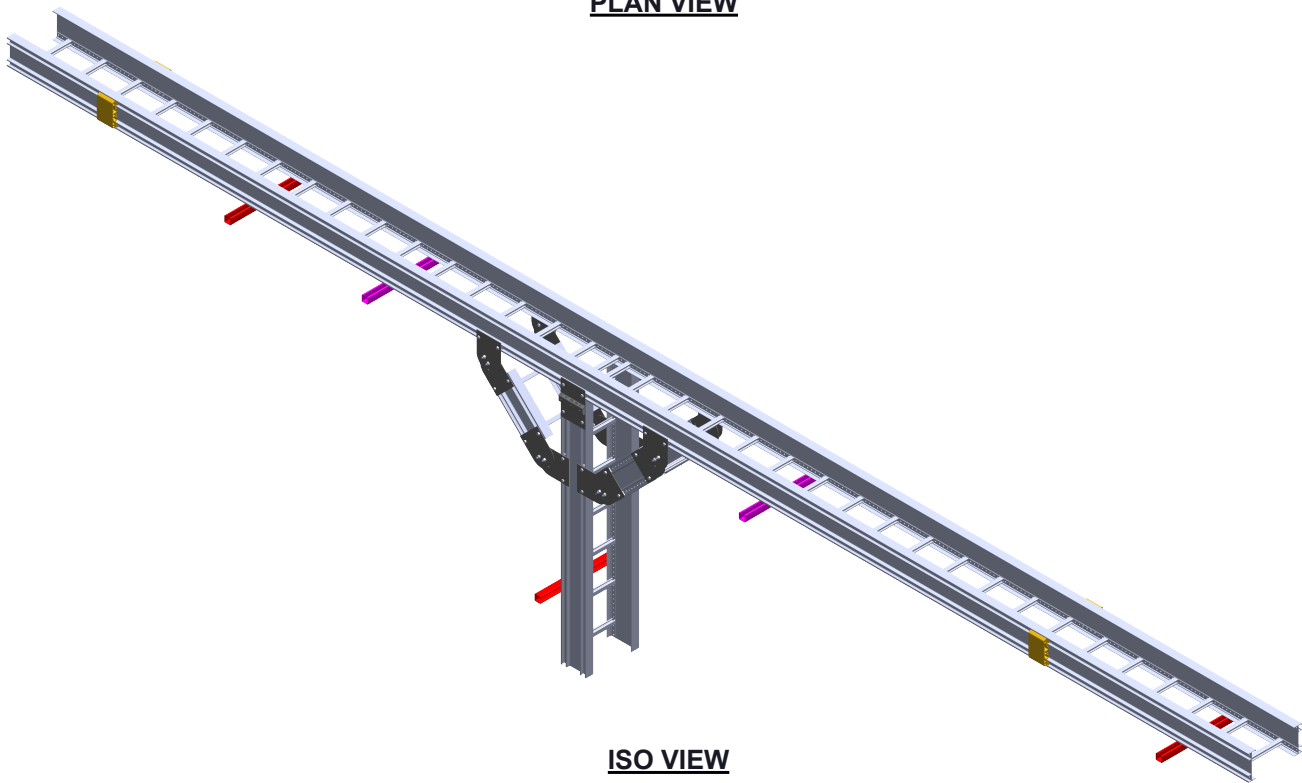
FIGURE 1: NEMA VE-2 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
Vertical Tee Up/Down**



PLAN VIEW

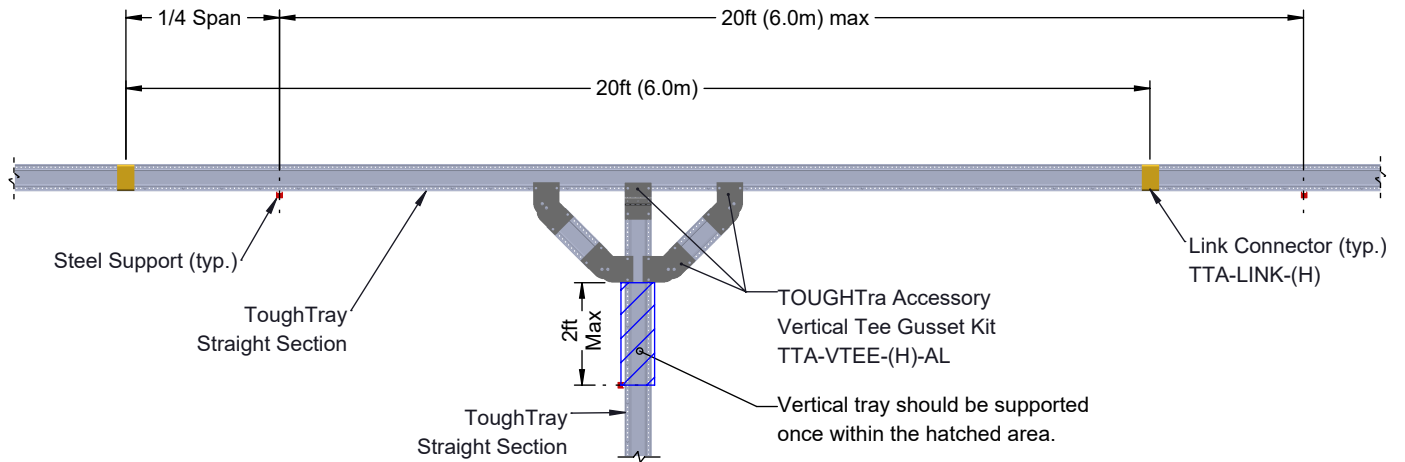


ISO VIEW

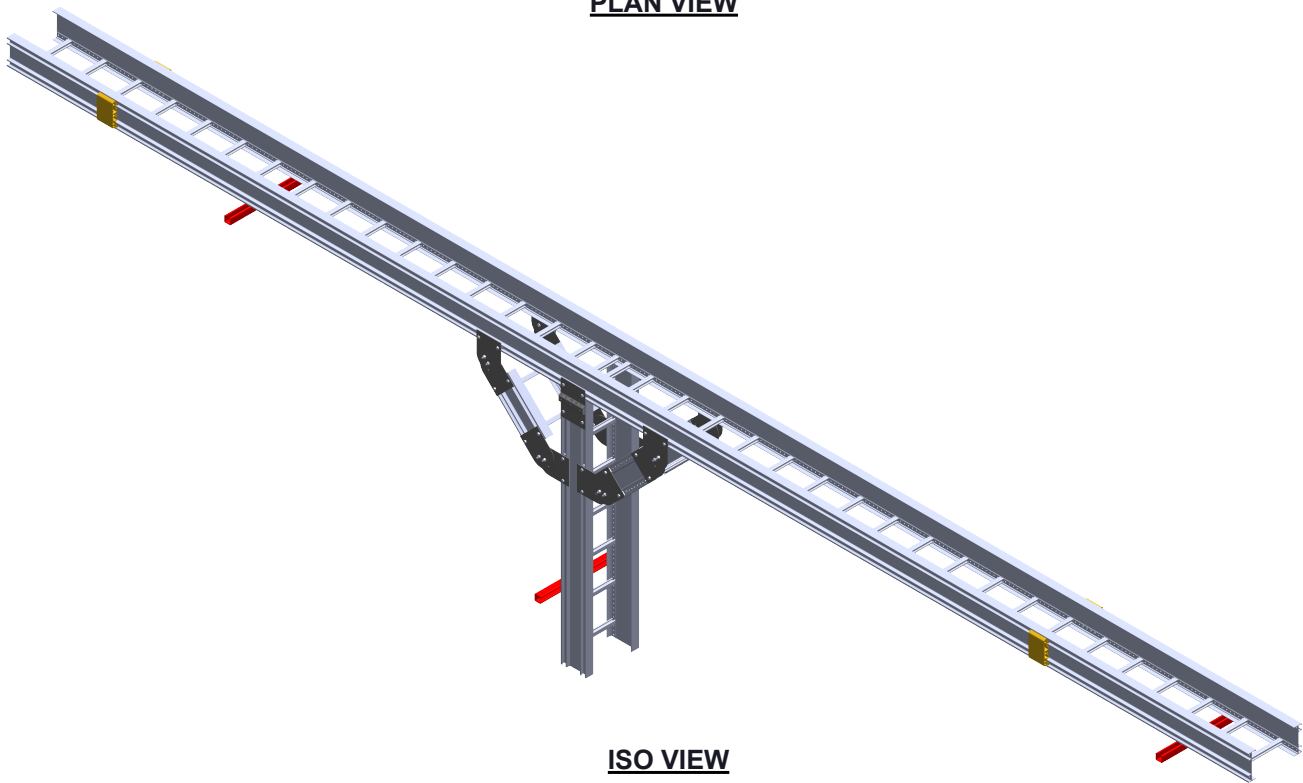
FIGURE 1: OPTION 1 SUPPORT RECOMMENDATION



**TOUGH SUPPORT SAVINGS for TOUGHTray
Vertical Tee Up/Down**



PLAN VIEW



ISO VIEW

PRELIMINARY
SUBJECT FOR TESTING
AND VALIDATION

FIGURE 2: OPTION 2 SUPPORT RECOMMENDATION