CT Innovations

TOUGH SUPPORT SAVINGS

CTI-TT-TSS-001

Engineered solutions designed and tested to surpass industry standards generating greater project ROI

Our DNA

With over 130 years of combined electrical and mechanical support systems experience, the CT Innovations leadership team set out to build an agile company thats focused on and dedicated to customers, not shareholders. In our view, great service is not a luxury. It is a necessity that too few deliver.

At CT Innovations, we focus on one thing and one thing only-our customers' needs. We believe in taking action, being easy to do business with, and being held accountable by those we serve. We are not all things to all people. We will; however, always strive to be our customers' preferred supplier in our space, and to be recognized as a company that consistently provides superior value, service, and innovation.

Company Motto:
"Do Better. Be Better."

CTI Model

Actions over Buzzwords

Responsiveness | Flexibility | Experience

All to often, suppliers try to make their product fit a need with fancy words and charts, delivering little actual customer value. At CTI we flipped that script. We started with the customers needs, and built our products and company around them.

Project Savings

Product value is often determined by a project's success. Whether its material, installation efficiency, engineering support, product availability, or just the ease of doing business, CT Innovations represents maximum savings.

Innovation

With engineering and field installation at our core, CT Innovations is focused on bringing value back to a stagnate market place. There is buzzword innovation, and there's innovation that actually delivers value.

Market Awareness

With more than 130yrs of electrical and mechanical field experience, CT Innovations has built its reputation by directly engaging with the market to continuously address limitations and proactively provide solutions.

Time Savings

With an ever increasing shortage of skilled workers, time management is more important than ever. From preliminary layouts and BOM building, to procurement and product installation, CTI can provide solutions.

Accountability

While most manufacturers today like to point fingers and avoid ownership, CT Innovations believes in accepting responsibility for one's actions and finding solutions to best service our customers' needs.

Subject Matter Experts

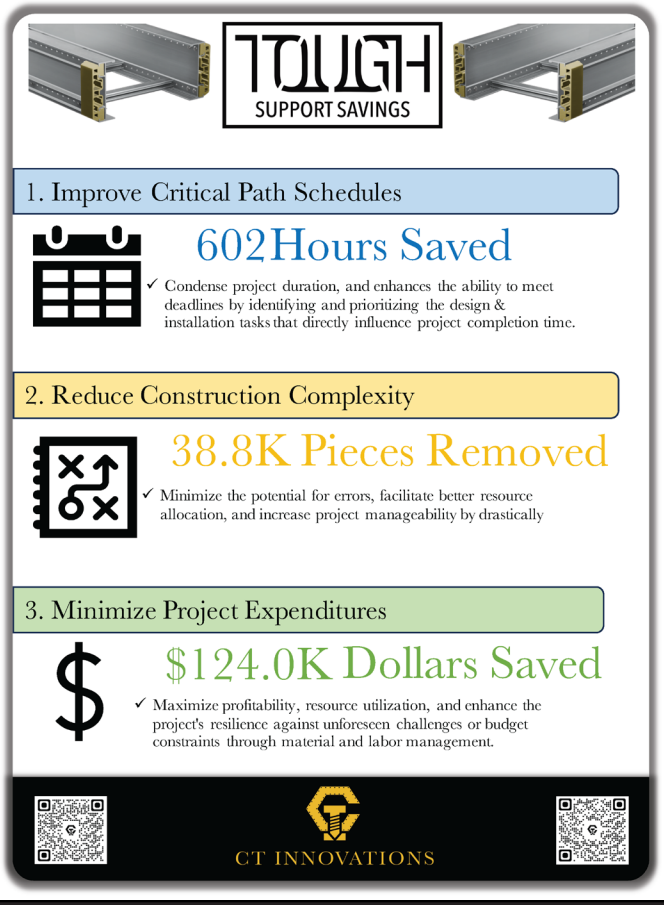
Would you like to talk to a manufacturer with actual experience? With experts skilled in product design, project coordination and field installation, CTI believes educating customers on relevant products and solutions dramatically improves a project's success.

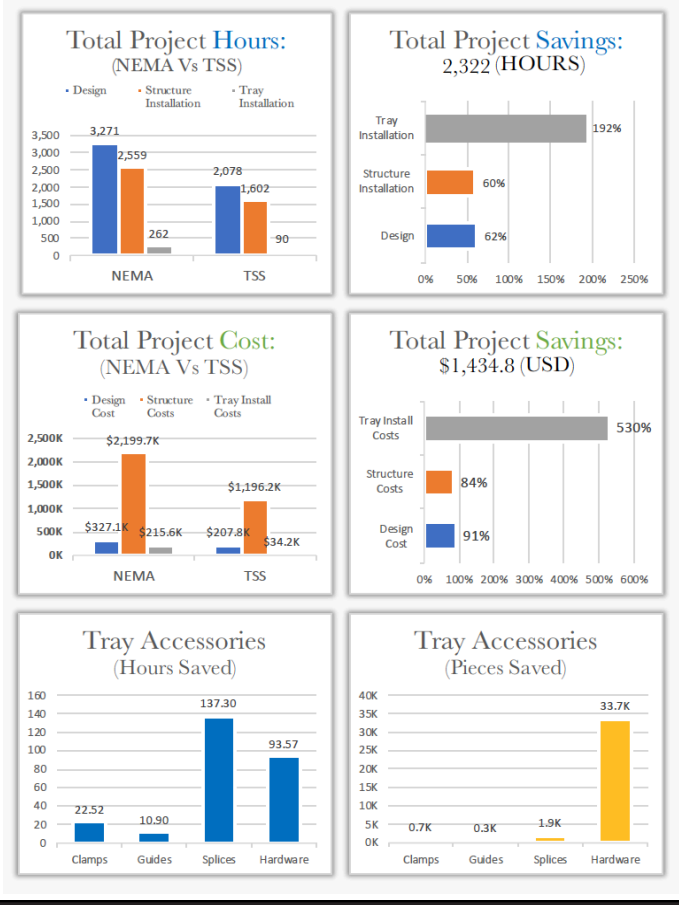
Engineering Services:

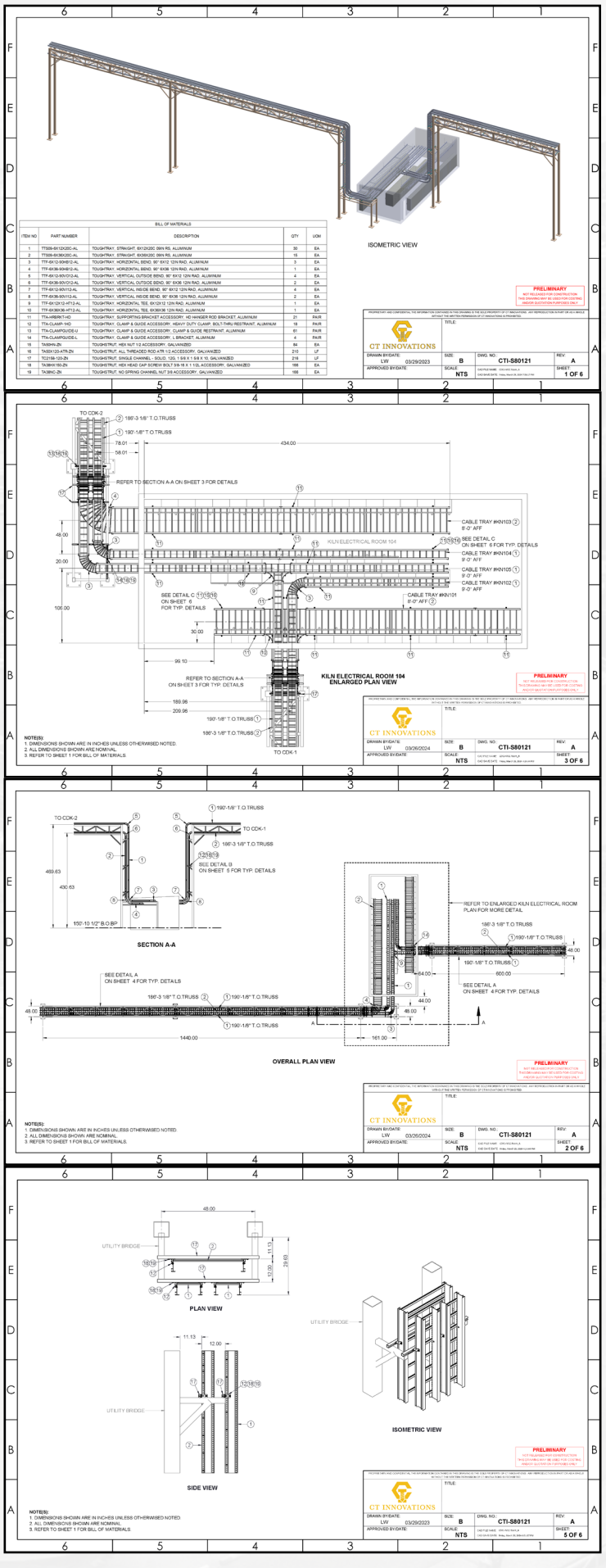
Optimization Delivered

Engineering Services is a highly experienced group of engineers dedicated to better servicing our customer's needs and providing turnkey solutions. With extensive backgrounds in electrical, structural, and mechanical engineering, this globally integrated team is ready to help deliver projects on schedule and to budget.

Discover Massive Savings with CTI's TSS Calculator







Services Available:

- Dynamic Load Calculations
- Static Load Calculations
- Support Optimization
- Shop Drawings
- Installation Details
- Take-Offs (BOM)
- Plan Drawings
- PE Stamps
- Cable Tray Layout
- Trayfill Calculation
- Specification Review
- Site Support
- 3D Model Generation
- Pipe Rack Design
- HVAC Rack Design
- MEP Rack Design
- ETO Product Design
- Seismic & NF Certification
- NEMA Certification
- IEC Certification
- UL Certification
- Pull & Slip Tests
- Salt Spray Tests
- Wind Certification

Minimize Risk
MAXIMIZE
Profitability

TOUGH
SUPPORT SAVINGS

Civil Structure & Design

- Modular Span Solutions
- Self Supporting Solutions
- Dynamic Load Certified
- Minimize Civil Structure
- Structural Design Services

Installers & Construction

- Eliminate Splice Plates
- Preinstalled Link Connectors
- 50% Less Hardware
- Maximum Site Adaptability
- Modular Assembly Solutions

Value & Simplicity

TOUGH Support Savings represents CTI's project optimization recommendations. Derived from years of working alongside end users, EPC's, engineers, distribution, and cable tray installers, CTI set out to create customer value from customer feedback. These manufacturer recommendations are fully complaint with NEMA VE 2 guidelines and supersede industry standard practices. Rest assured that each recommendation underwent extensive application testing to validate product longevity and project practicality.

Project Optimization

- Engineering Resources
- Design Hours
- Logistic Costs
- Material Handling
- Construction Schedule
- Site Resources
- Project Schedule
- Raw Material Content

Inspection & Review

- Eliminate Exp. Gap Setting
- Eliminate Heat Stain
- Eliminate Weld Smoke
- Eliminate Weld Cracks
- Eliminate Weld Uncertainty

Procurement & Expediting

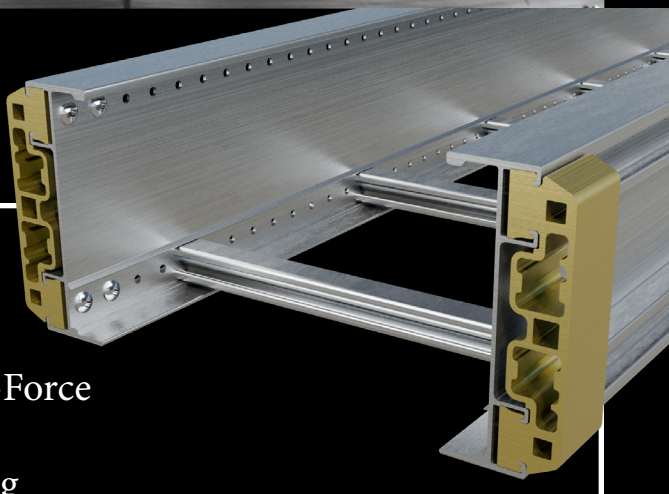
- Estimate Quicker
- Quantify Less To Buy Less
- Ship & Expedite Less
- Coordinate & Manage Less
- Instant Project Tracking

TOUGHTray:

Innovation

The embodiment of a cable tray system without limitations: With a modular platform this aluminum ladder tray is engineered to provide superior support solutions and maximum flexibility. Derived from years of working alongside engineers and installers, CTI set out to create customer value from customer feedback. Built from the ground up around project solutions, this cable ladder system represents the GOLD standard of cable support solutions.

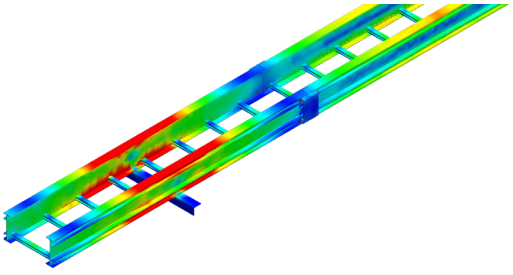
Key Benefits

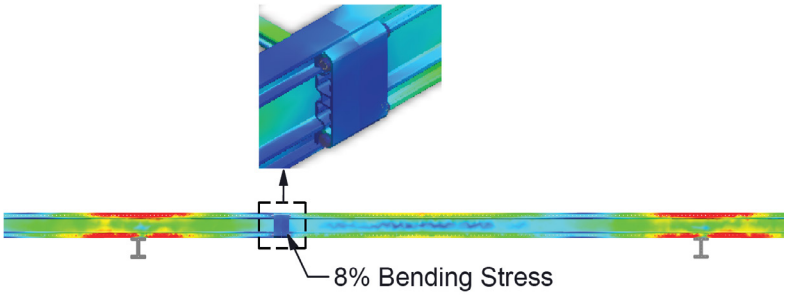


- Eliminate Supports / Minimize Civil Structure
- Eliminate Splice Plates / Reduce Wasted Labor
- Dynamic Load Certified: Wind / Snow / Ice / G-Force
- Superior Site Flexibility / Modular Assembly
- Eliminate Custom Hangers / Universal Mounting
- Maximize Safety / No Hot Work

Moments & Bending Stress

Continuous straight section tray runs create moment connections between each tray section. Throughout the entire continuous straight run, the cable tray will be subjected to positive and negative bending stress. Bending stress should be minimized by installing link connectors at ¼-span location within the support span. Refer to recommendation Section-2, Figure-2.1C.



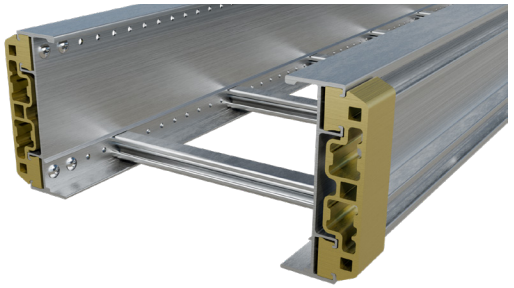


Thermal Expansion & Contraction

Continuous straight section runs thermally expand and contract as the ambient site temperature increases and decreases. They must be engineered to allow correct expansion and contraction of the cable tray system. It is recommended expansion connectors be of the self-supporting type located at 1/4 span to provide maximum tray rigidity, thermal dynamic system performance and structural design savings. Refer to recommendations Section-7 & 8.

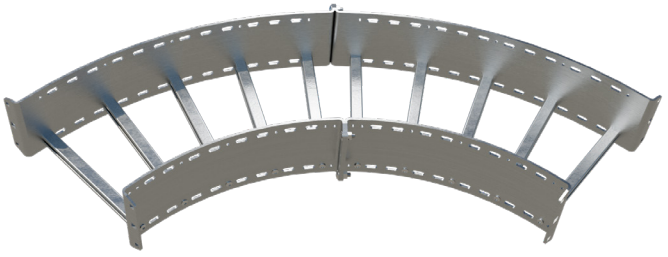
TOUGHLink & Integral-Link

Link connectors are used to link all straight sections and fittings. TOUGHLink connectors are supplied factory pre-installed on all straight sections with fittings supplied incorporating INTEGRAL-Links. Tested and certified to NEMA VE 1 for ¼-span and ½-span location. TOUGHLinks are expansion ready and deliver the fastest method of cable tray installation. Superior performance where it is needed most. Refer to recommendations Section-2.



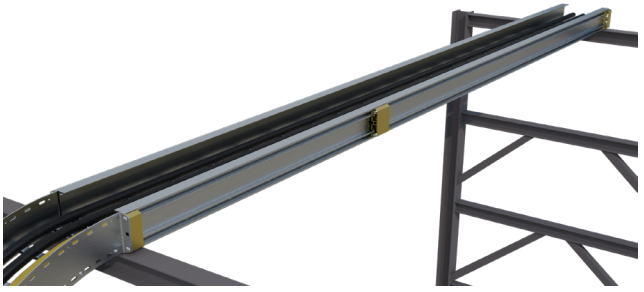
Engineered Modular Fittings

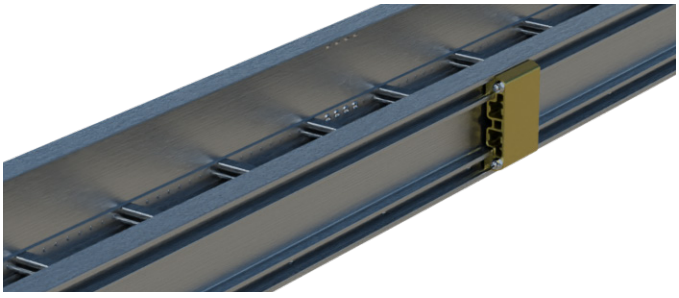
Modular fittings provide angles from 30° to 180° with engineered reinforced stress points to better support the cable pathway. Complete modular interchangeability maintains the fitting radii. Designed for modular 30° and 45° fittings to be linked together forming 60° and 90°. Modular fittings from 105° to 180° deliver superior design flexibility and site constructibility to help mitigate critical path schedule risks. Refer to recommendations Section-5.



Engineered Modular Spans

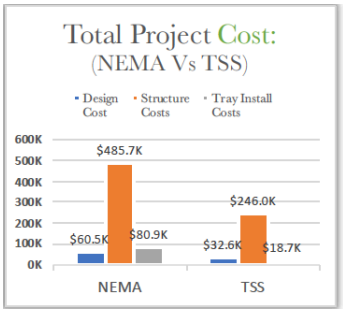
Engineered modular spans provide superior product standardization and design flexibility to simplify material handling and site construction. TOUGHTray strength and performance provides support spans to 30FT. Modular 12FT and 20FT straight sections are linked together to construct the span you need. Refer to recommendations Section-5.

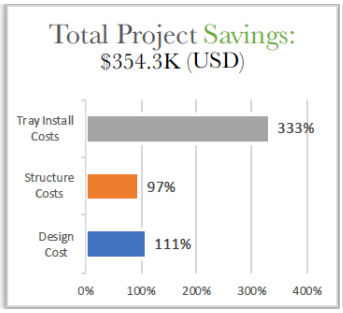


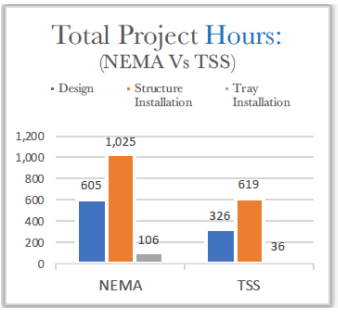


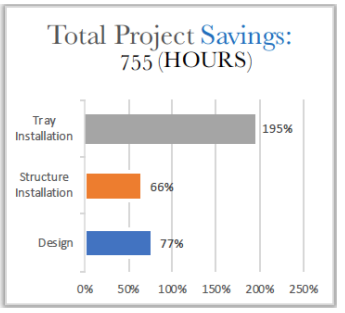
Optimization Savings Calculator

TOUGH Support Savings is a comprehensive portfolio of recommendations that deliver better efficiency and savings throughout a cable tray project cycle. Calculate project savings using the QR Code to download a TSS Calculator. Simply input a cable tray BOM to generate a detailed Optimization Report.









Manufacturer
Recommendations

CT Innovations is proud to present a comprehensive portfolio of recommendations focused on TOUGHTray solutions that optimize cable tray support structure. Providing superior design flexibility and efficiency for all tray widths and radii; TOUGH Support Savings will mitigate project constraints to deliver cable tray projects more efficiently and profitably.

By optimizing what our customers need, we help to:

- *Mitigate construction schedule critical-path risks.*
- *Reduce structural engineering design complexity and hours.*
- *Reduce civil structural materials and associated work costs.*
- *Improve structural engineering design efficiency and productivity.*
- *Deliver the lowest total installed project cost cable ladder tray system.*

Industry Leading Solutions help our customers "design to use less and plan to do more".

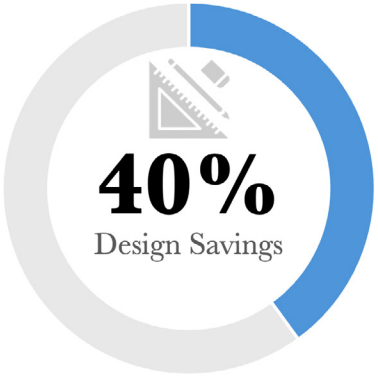
What does optimization mean?
"The action of making the best or most effective use of a situation or resource"

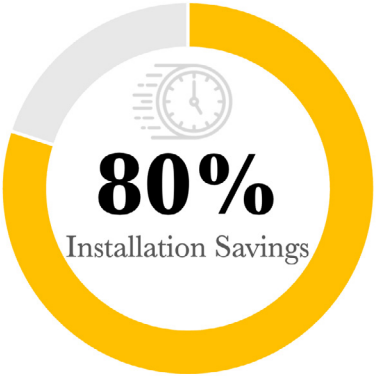
How does optimizataon corolate to TOUGH Support Savings?
"The use of proven recommendations to deliver the most effective cable tray system design using less raw materials and human resources to deliver projects on schedule and budget"

Optimization Delivers A Savings Value
Each design recommendation is provided a corresponding savings value for:

- Design Hours - The amount of engineering & design time removed from FEED
- Raw Material - The amount of physical material completely removed from the project
- Installation Time - The amount of installation time saved when installing the system

These are expressed as shown in the below examples.





TSS Recommendations Apply To All TOUGHTray Widths & Fitting Radii (including 36in)

TOUGH SUPPORT SAVINGS

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Continious
Straight
Runs

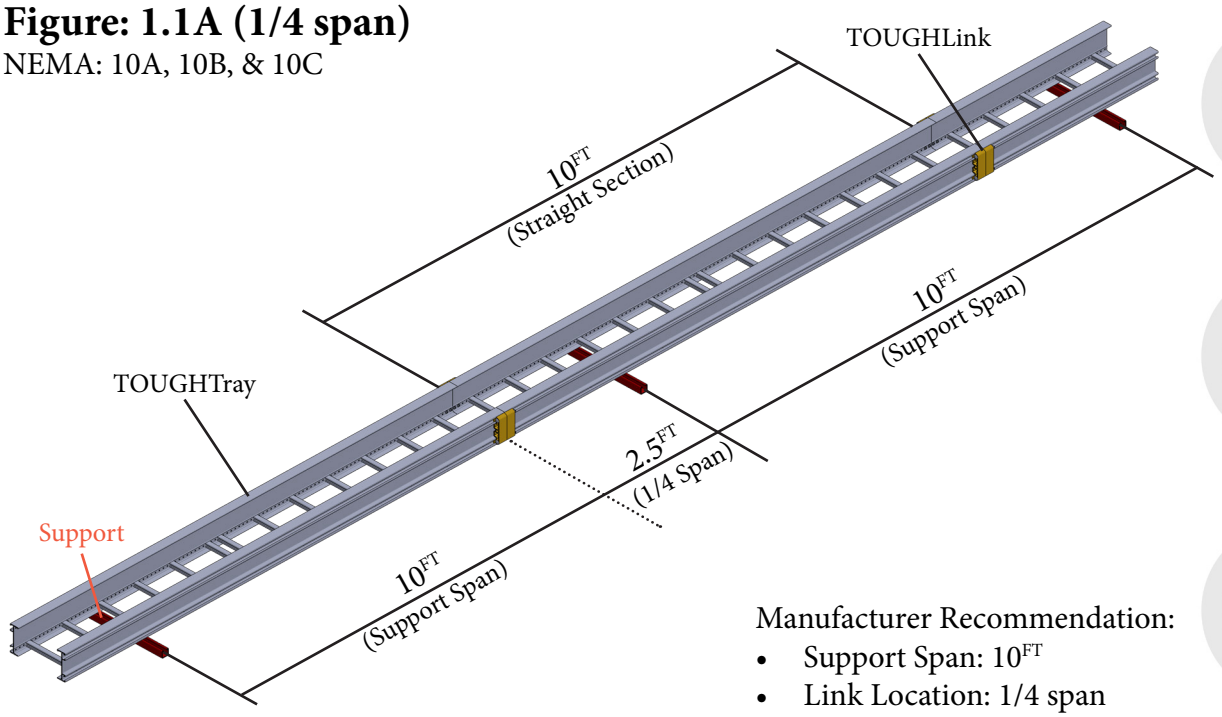
Support Recommendations for Horizontal & Vertical Applications

1.1 Horizontal Support Solutions: 10^{FT}

TOUGHLink can be located anywhere within a support span for complete design flexibility. Optimization is achieved by designing the maximum support span for the selected cable tray design load.

Figure: 1.1A (1/4 span)

NEMA: 10A, 10B, & 10C



0% Design Savings

20% Installation Savings

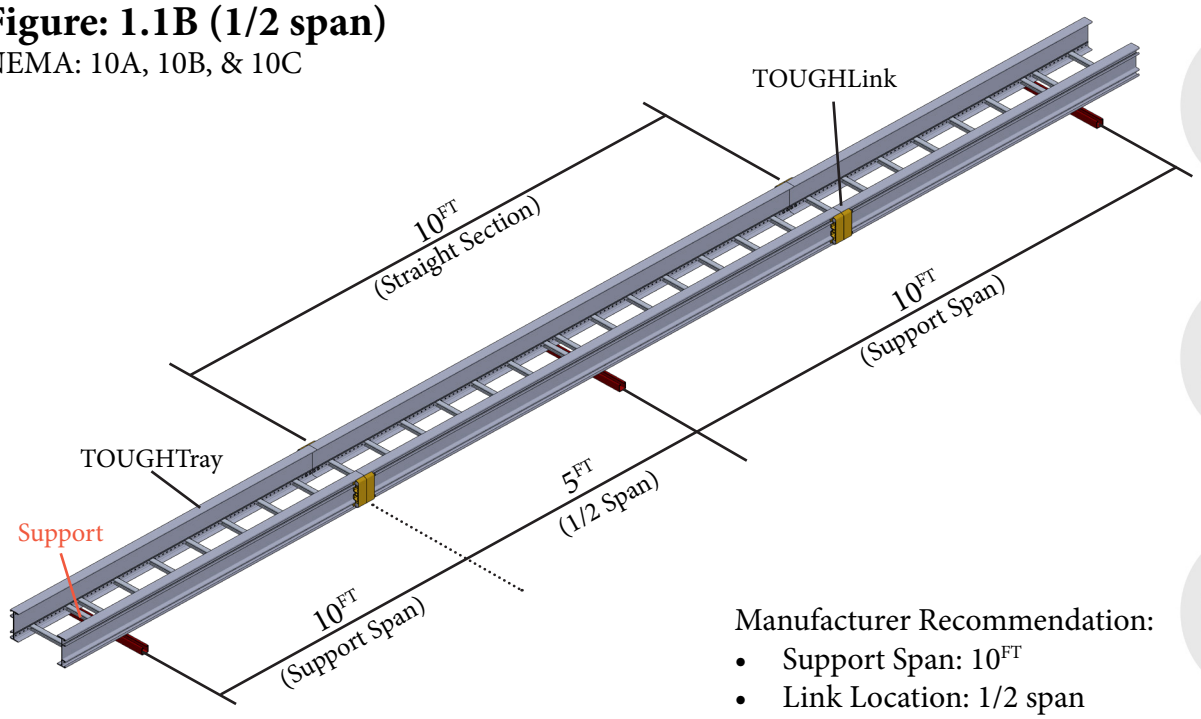
0% Material Savings

Manufacturer Recommendation:

- Support Span: 10^{FT}
- Link Location: 1/4 span

Figure: 1.1B (1/2 span)

NEMA: 10A, 10B, & 10C



0% Design Savings

20% Installation Savings

0% Material Savings

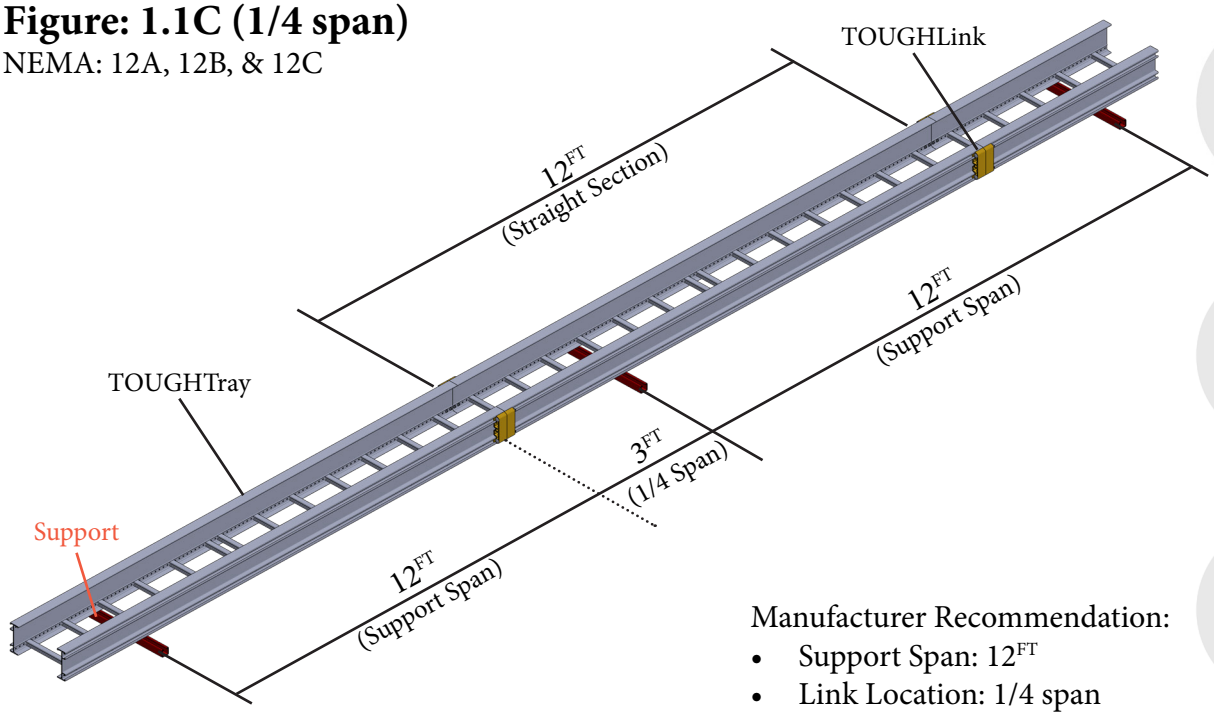
Manufacturer Recommendation:

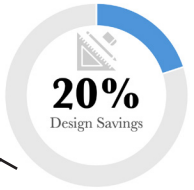
- Support Span: 10^{FT}
- Link Location: 1/2 span

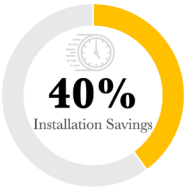
1.1 Horizontal Support Solutions: 12FT

TOUGHLink can be located anywhere within a support span for complete design flexibility. Optimization is achieved by designing the maximum support span for the selected cable tray design load.

Figure: 1.1C (1/4 span)
NEMA: 12A, 12B, & 12C

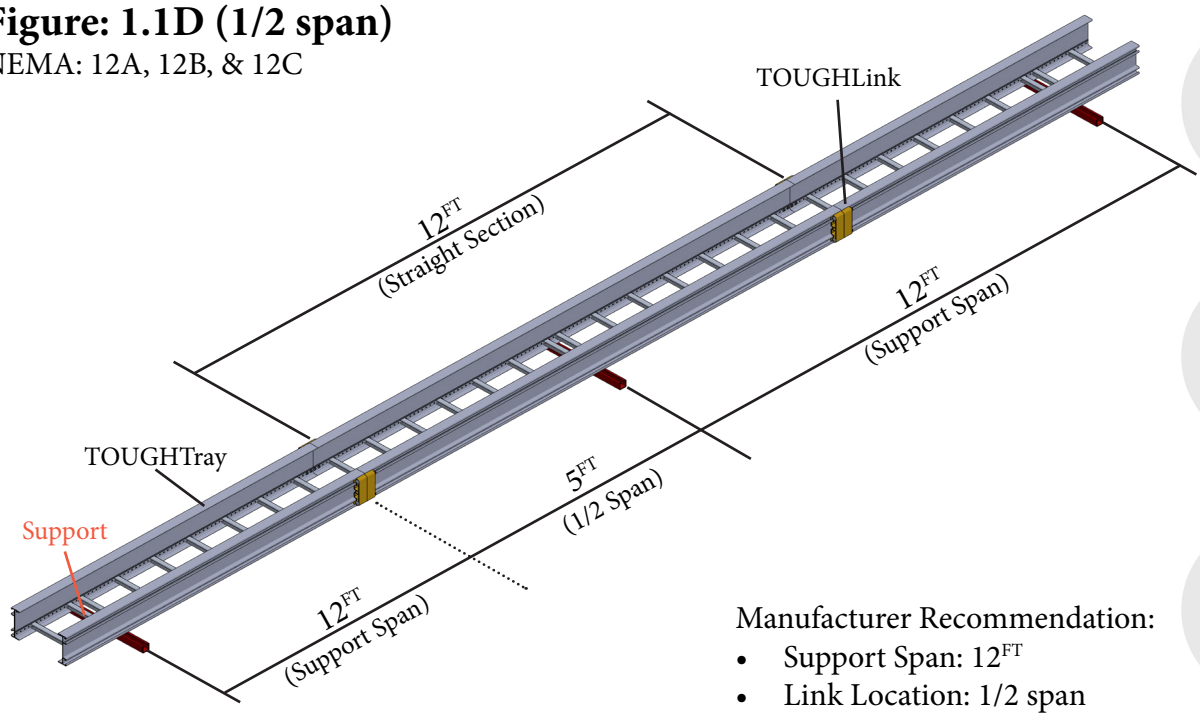


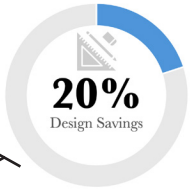


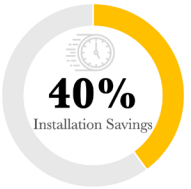


Manufacturer Recommendation:
- Support Span: 12FT
- Link Location: 1/4 span

Figure: 1.1D (1/2 span)
NEMA: 12A, 12B, & 12C







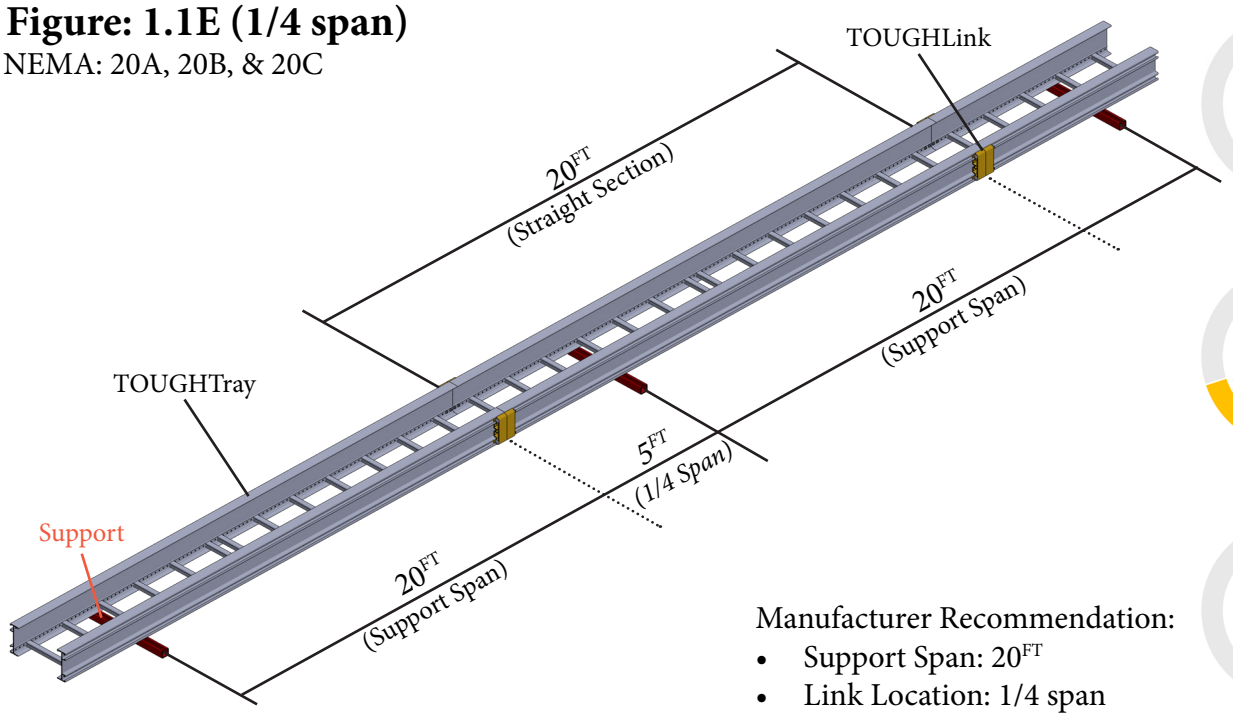
Manufacturer Recommendation:
- Support Span: 12FT
- Link Location: 1/2 span

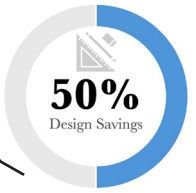
1.1 Horizontal Support Solutions: 20FT

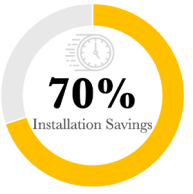
TOUGHLink can be located anywhere within a support span for complete design flexibility. Optimization is achieved by designing the maximum support span for the selected cable tray design load.

Figure: 1.1E (1/4 span)

NEMA: 20A, 20B, & 20C





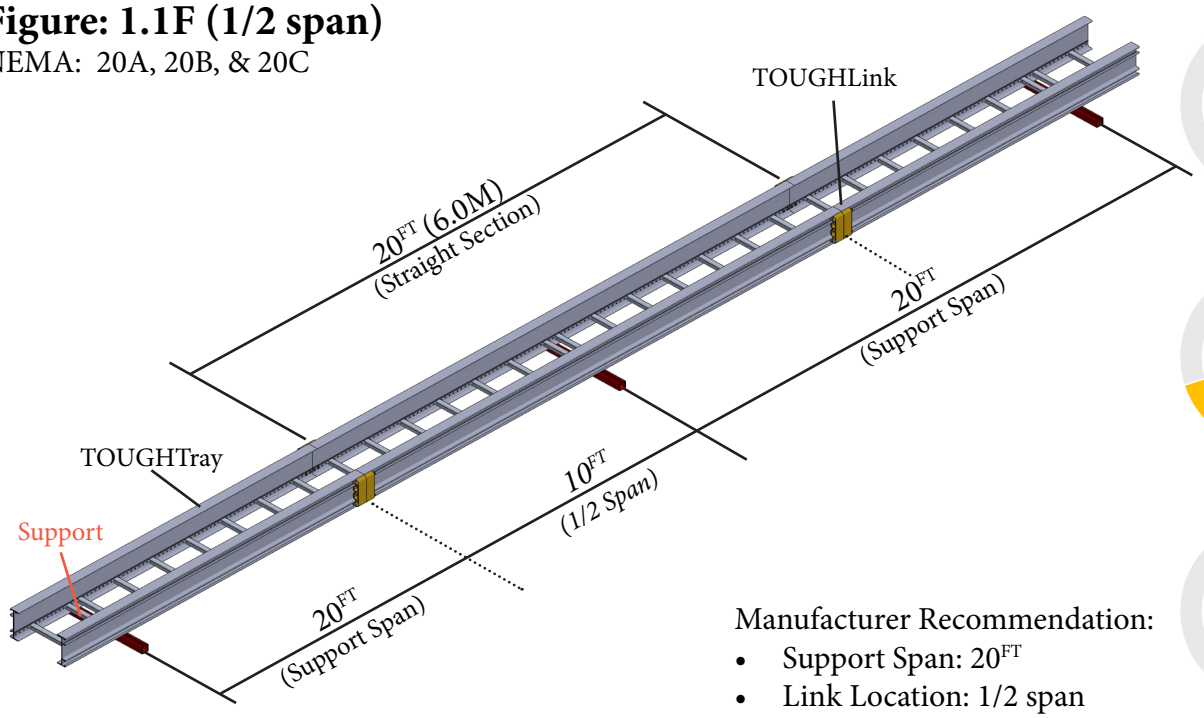


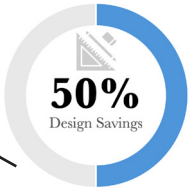
Manufacturer Recommendation:

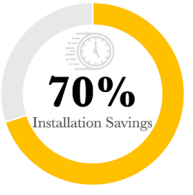
- Support Span: 20FT
- Link Location: 1/4 span

Figure: 1.1F (1/2 span)

NEMA: 20A, 20B, & 20C







Manufacturer Recommendation:

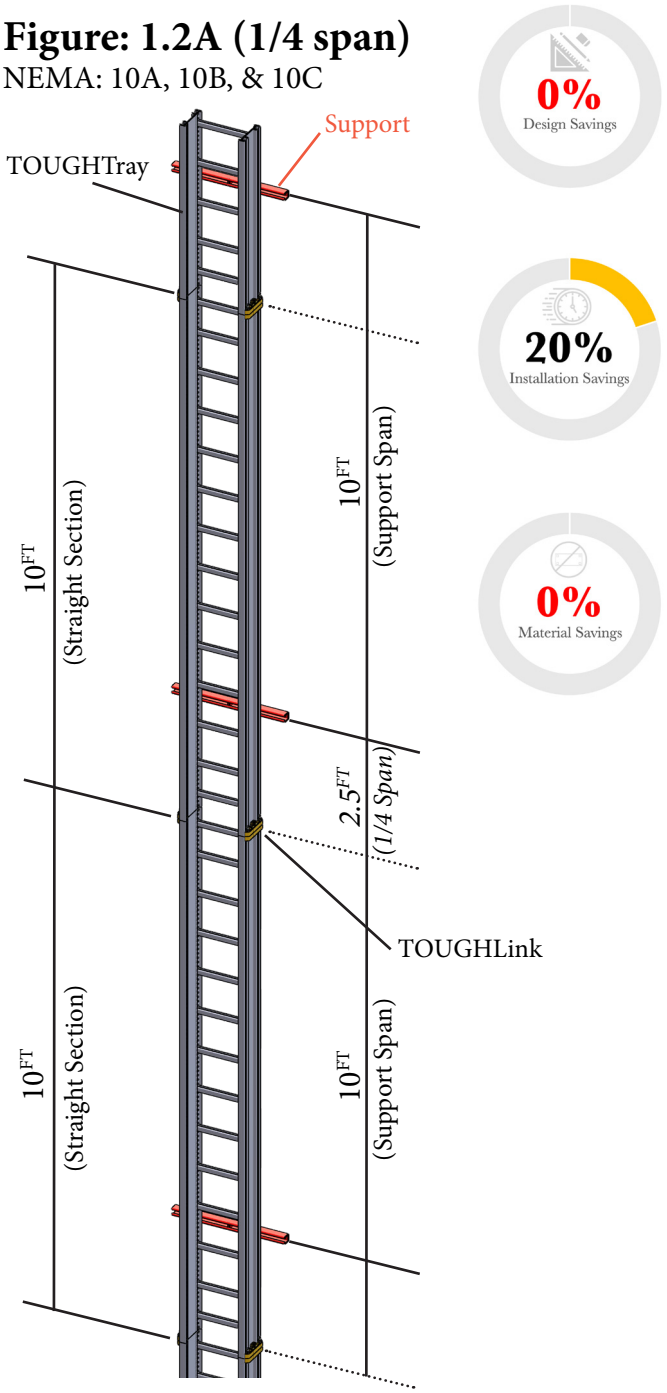
- Support Span: 20FT
- Link Location: 1/2 span

1.2 Vertical Support Solutions: 10FT

TOUGHLink can be located anywhere within a support span for complete design flexibility. Should vertical continuous run lengths necessitate expansion joints, refer to Section 7.0.

Figure: 1.2A (1/4 span)

NEMA: 10A, 10B, & 10C

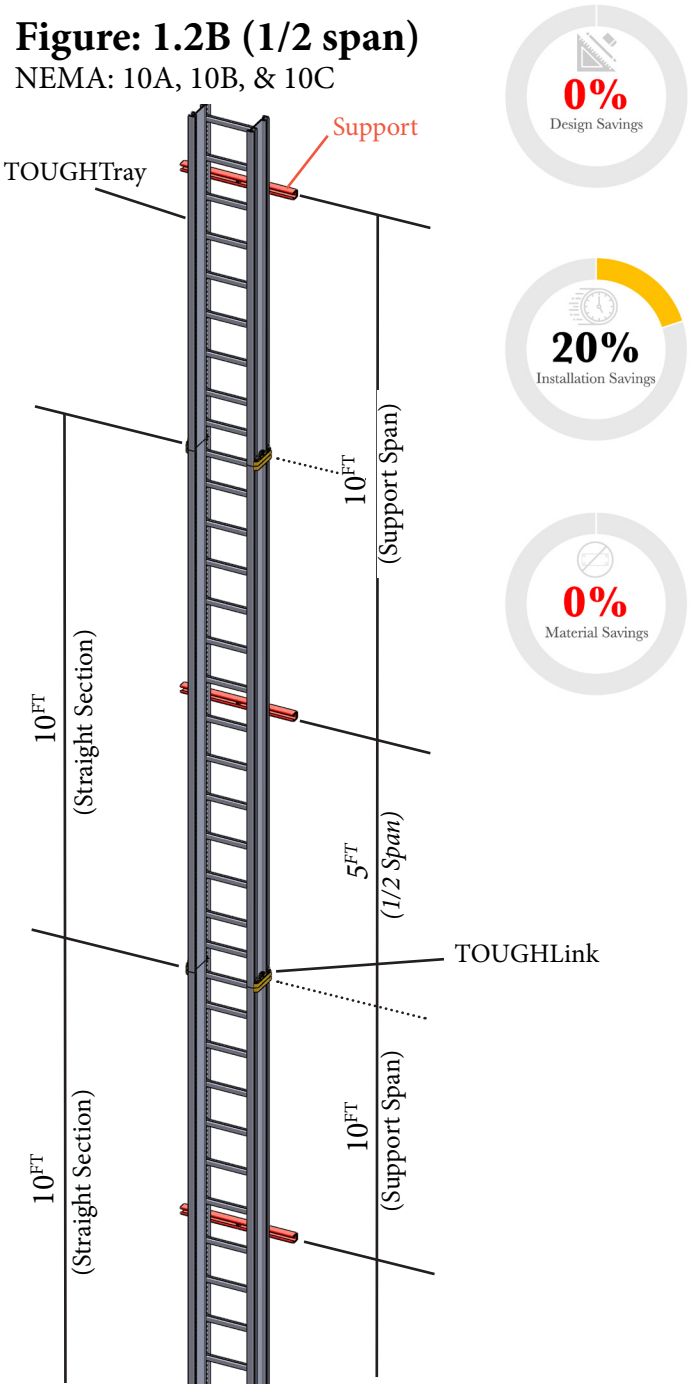


Manufacturer Recommendation:

- Support Span: 10FT
- Link Location: 1/4 span

Figure: 1.2B (1/2 span)

NEMA: 10A, 10B, & 10C



Manufacturer Recommendation:

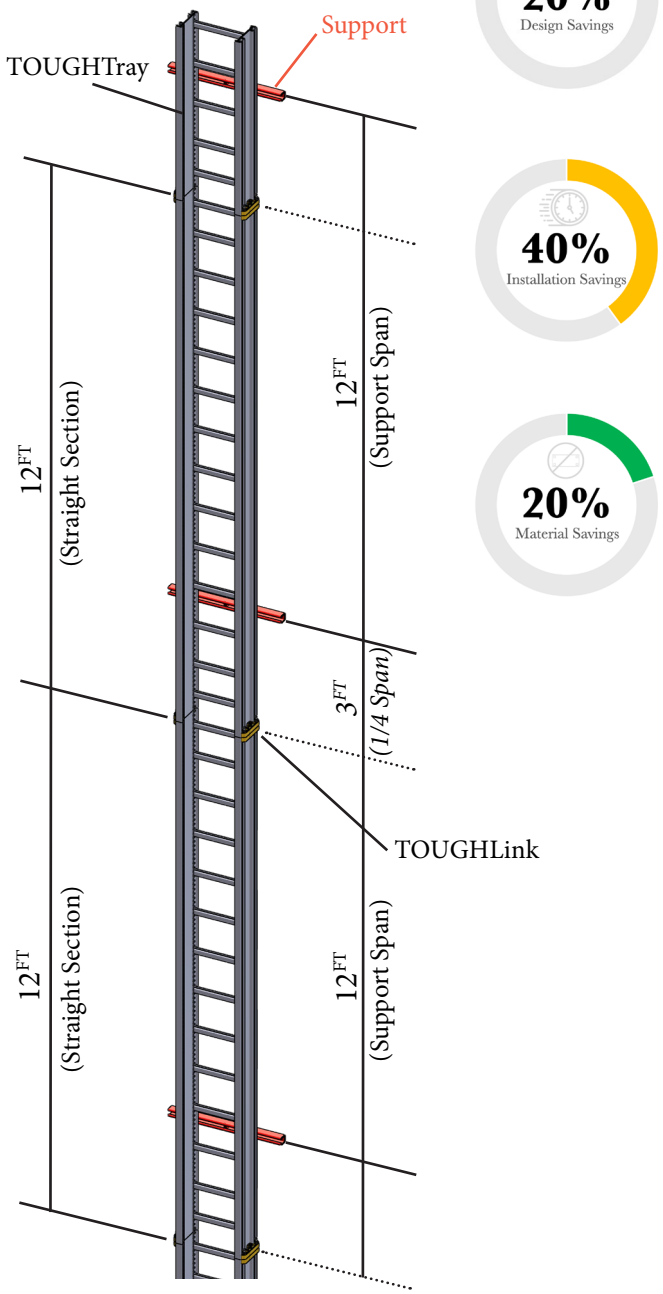
- Support Span: 10FT
- Link Location: 1/2 span

1.2 Vertical Support Solutions: 12FT

TOUGHLink can be located anywhere within a support span for complete design flexibility. Should vertical continuous run lengths necessitate expansion joints, refer to Section 7.0.

Figure: 1.2C (1/4 span)

NEMA: 12A, 12B, & 12C

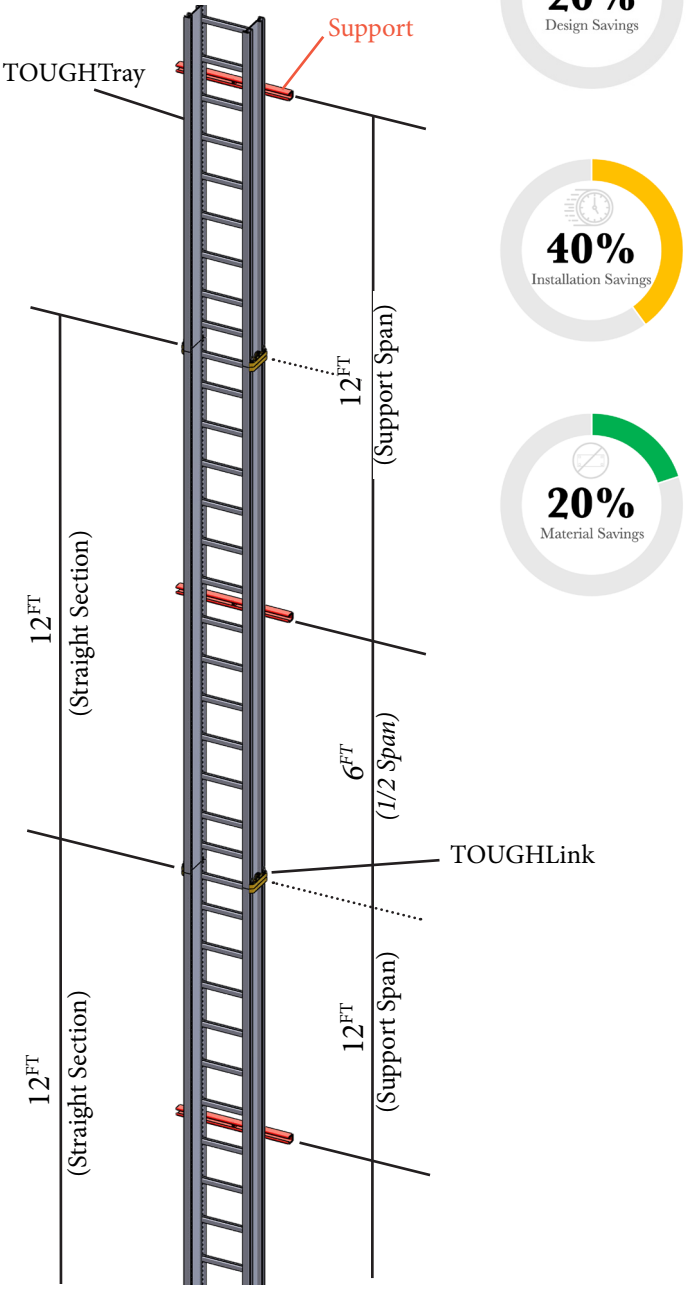


Manufacturer Recommendation:

- Support Span: 12FT
- Link Location: 1/4 span

Figure: 1.2D (1/2 span)

NEMA: 12A, 12B, & 12C



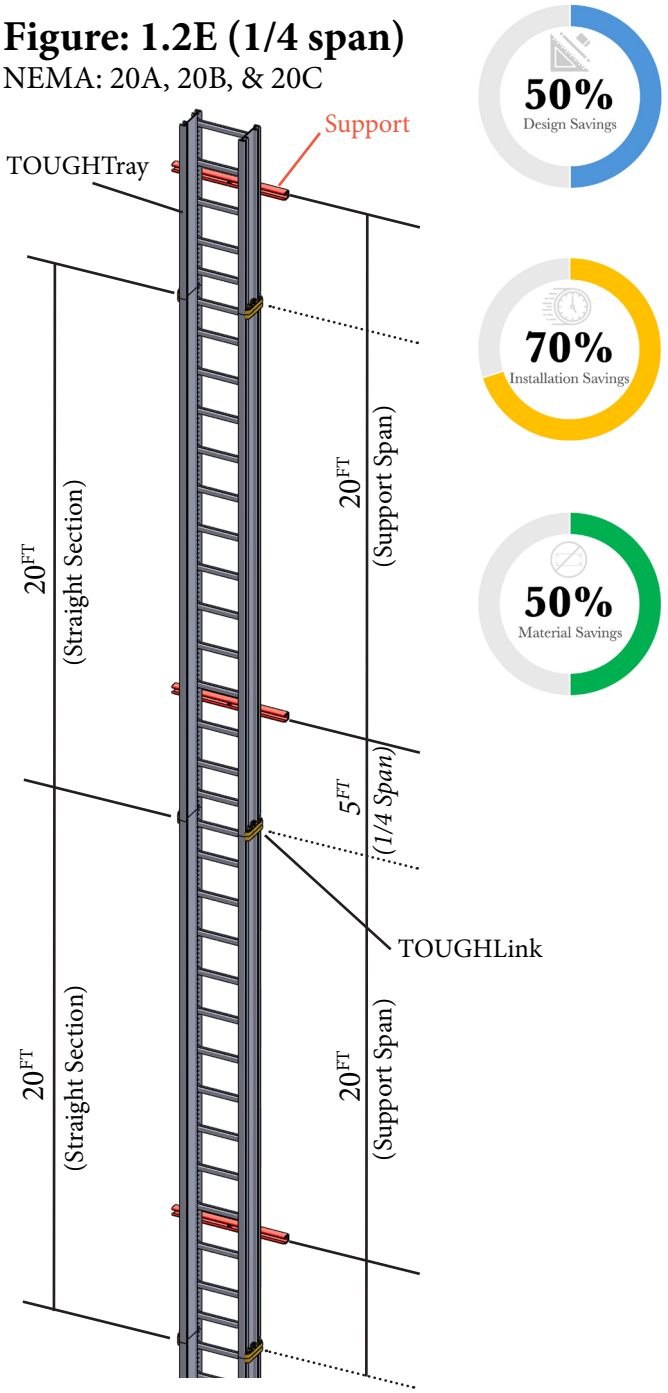
Manufacturer Recommendation:

- Support Span: 12FT
- Link Location: 1/2 span

1.2 Vertical Support Solutions: 20FT

TOUGHLink can be located anywhere within a support span for complete design flexibility. Should vertical continuous run lengths necessitate expansion joints, refer to Section 7.0.

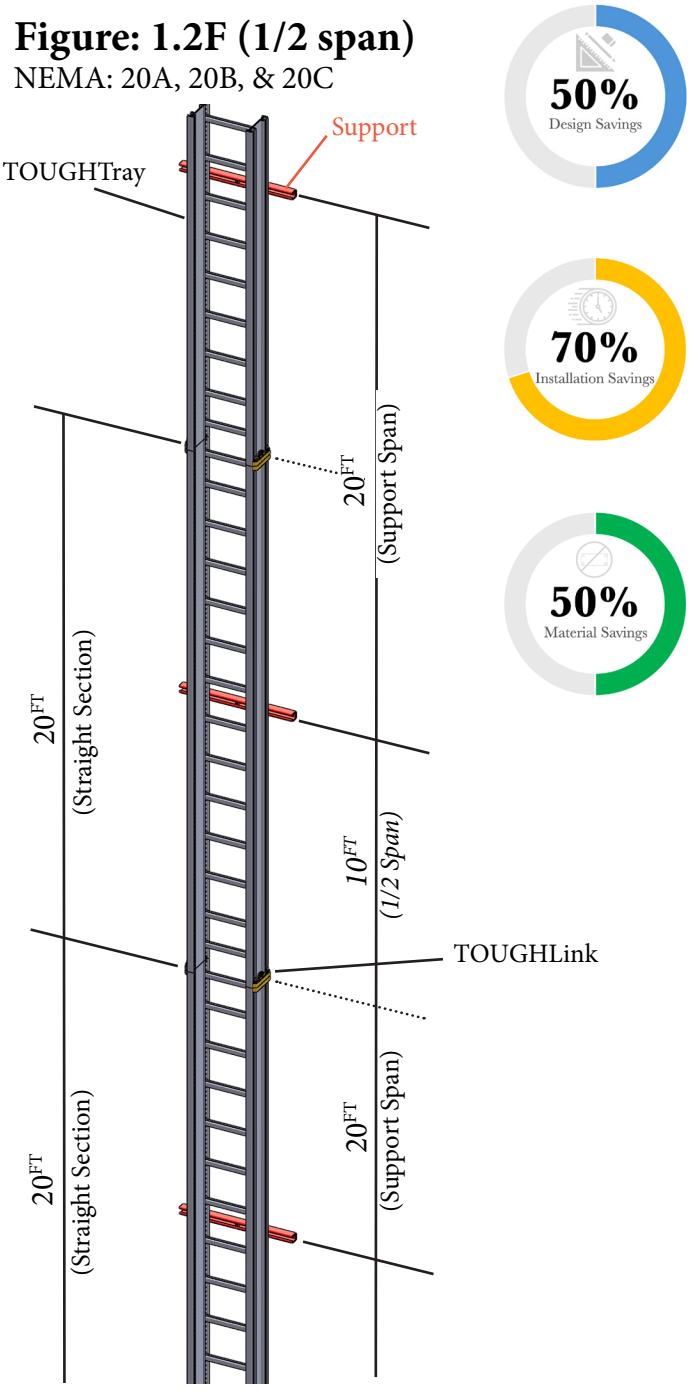
Figure: 1.2E (1/4 span)
NEMA: 20A, 20B, & 20C



Manufacturer Recommendation:

- Support Span: 20FT
- Link Location: 1/4 span

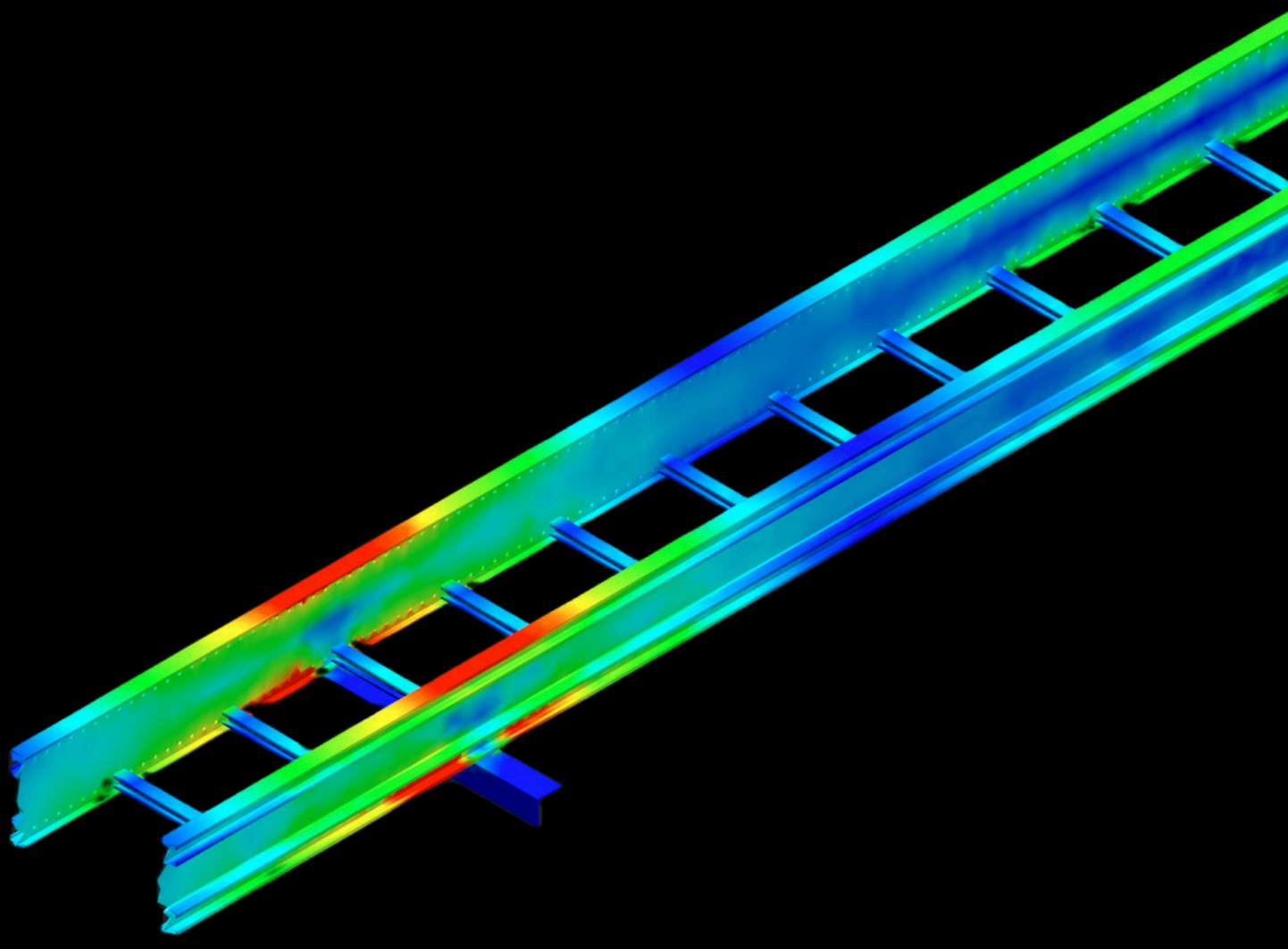
Figure: 1.2F (1/2 span)
NEMA: 20A, 20B, & 20C

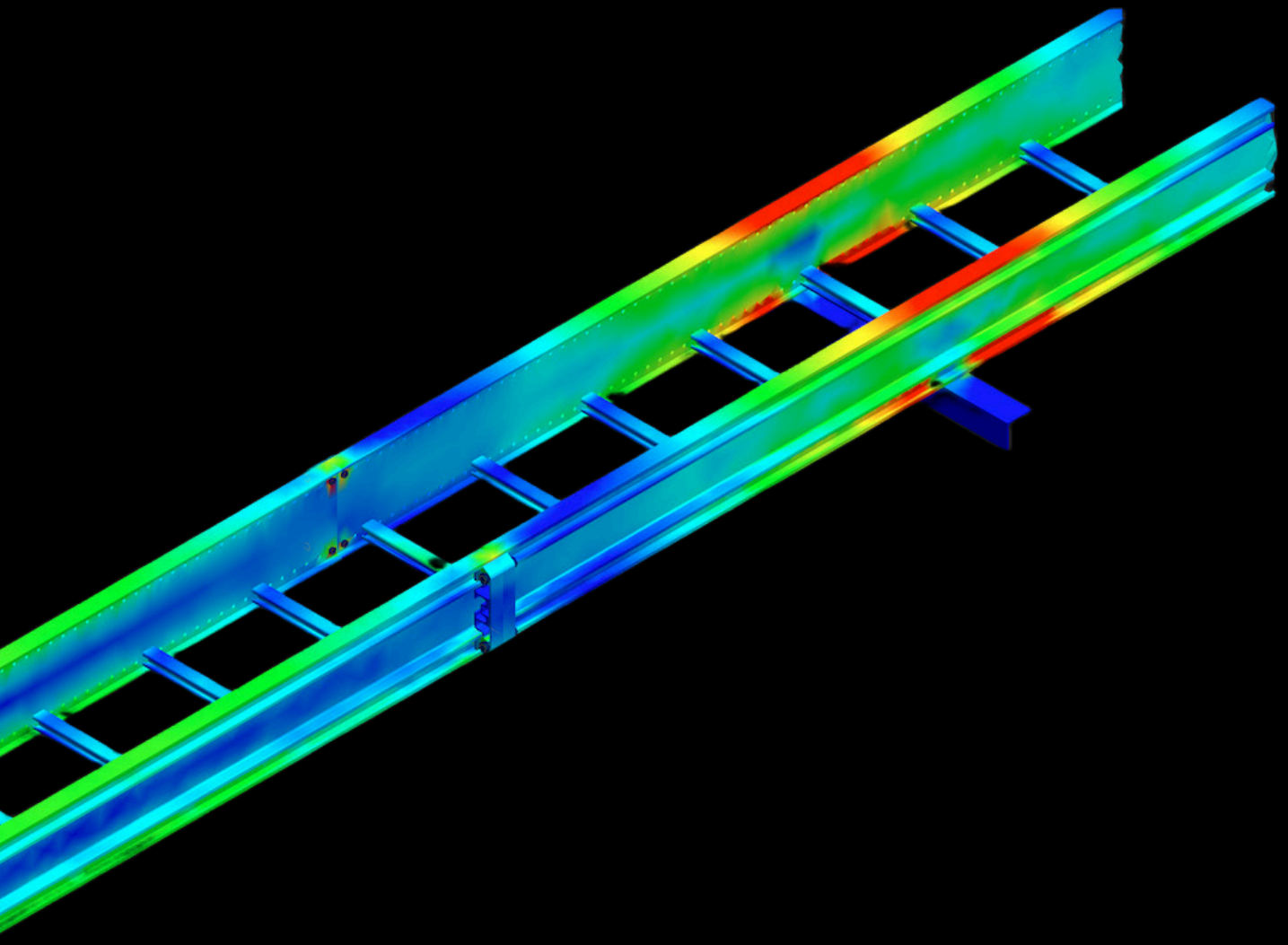


Manufacturer Recommendation:

- Support Span: 20FT
- Link Location: 1/2 span

Moment Analysis





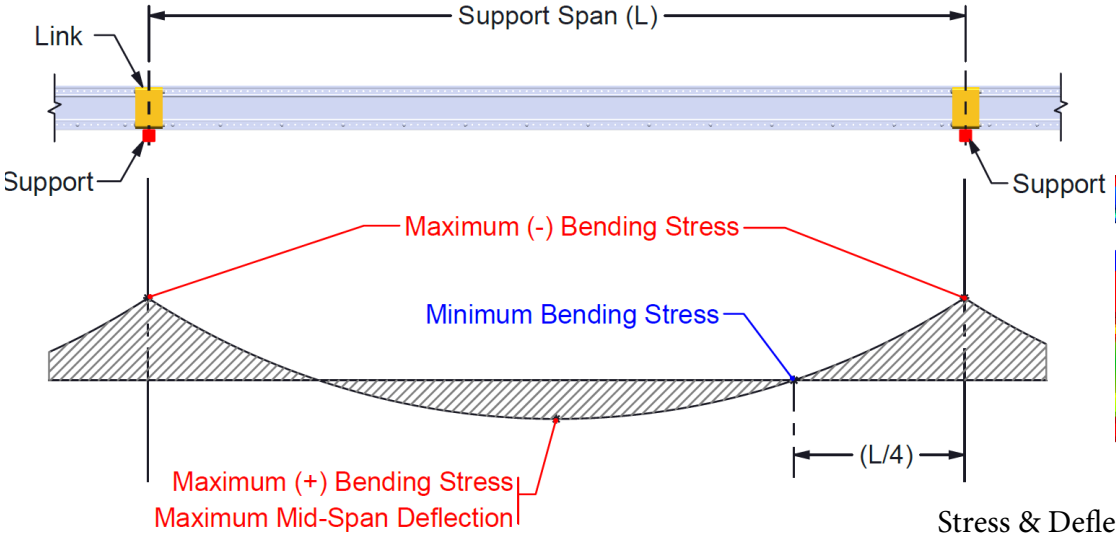
Bending Stress & Deflection Performance

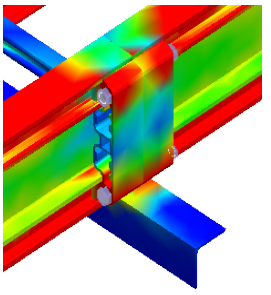
2.1 Bending Stress & Deflection: 10^{FT}, 12^{FT} & 20^{FT}

Continuous straight runs are subjected to bending moments. The tray and link connectors are subjected to both (+) and (-) bending stress. The link connector location within the continuous straight run will determine the severity of (+/-) bending stress, tray rigidity and the resultant mid-span tray deflection.

Figure: 2.1A (Over Support)

Load Class: ALL



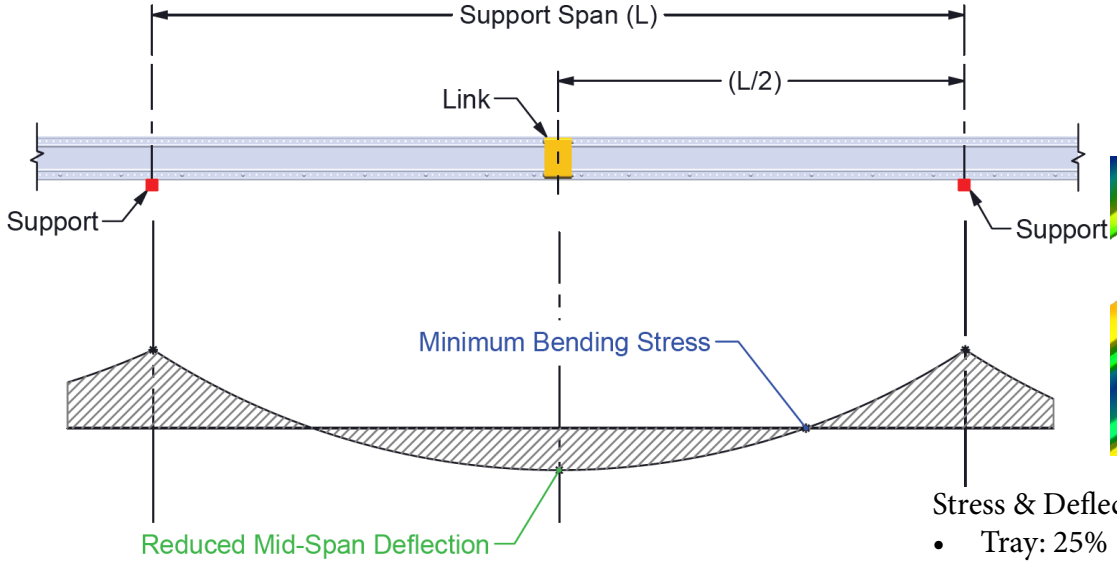


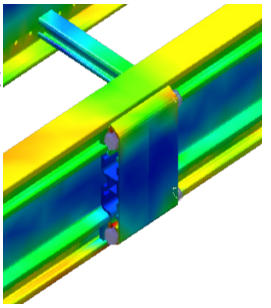
Stress & Deflection Performance:

- Tray: 100% (-) Bending Stress
- Link: 100% (+) Bending Stress

Figure: 2.1B (1/2 Span)

Load Class: ALL





Stress & Deflection Performance:

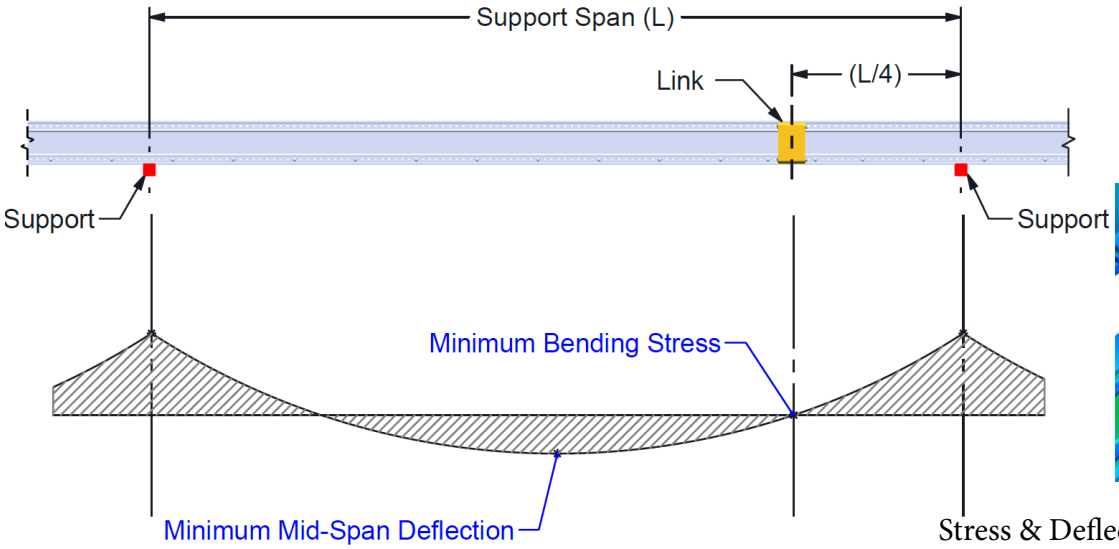
- Tray: 25% (+) Bending Stress
- Link: 25% (+) Bending Stress

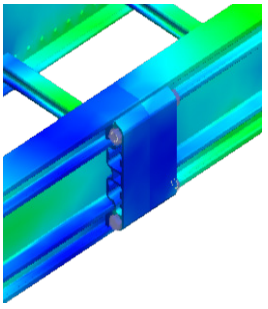
2.1 Bending Stress & Deflection: 10^{FT}, 12^{FT} & 20^{FT}

Continuous straight runs are subjected to bending moments. The tray and link connectors are subjected to both (+) and (-) bending stress. The link connector location within the continuous straight run will determine the severity of (+/-) bending stress, tray rigidity and the resultant mid-span tray deflection.

Figure: 2.1C (1/4 Span)

Load Class: ALL





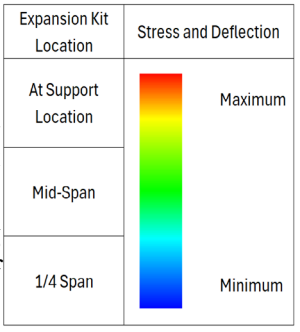
Stress & Deflection Performance:

- Tray: 8% (+/-) Bending Stress
- Link: 8% (+/-) Bending Stress

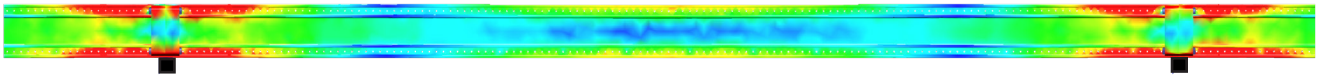
Figure: 2.1D

LINK Positioning

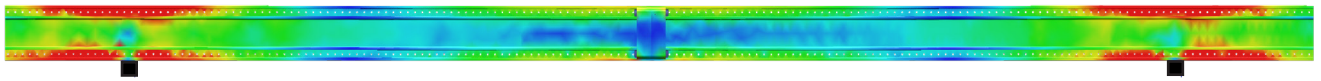
The positioning of the LINK directly correlates to the amount of stress and deflection the tray system will encounter. The less stress placed on the weakest part of the system (Unions), the more rigid the system becomes which helps minimize deflection. In addition to standard union connections, positioning expansion connections correctly will greatly increase rigidity and reduce risk of binding (see Section 7.0).



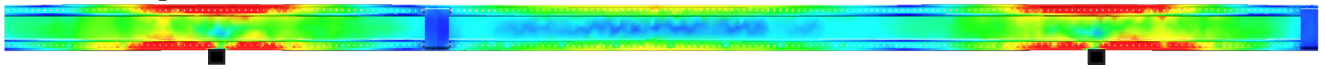
LINK @ Support



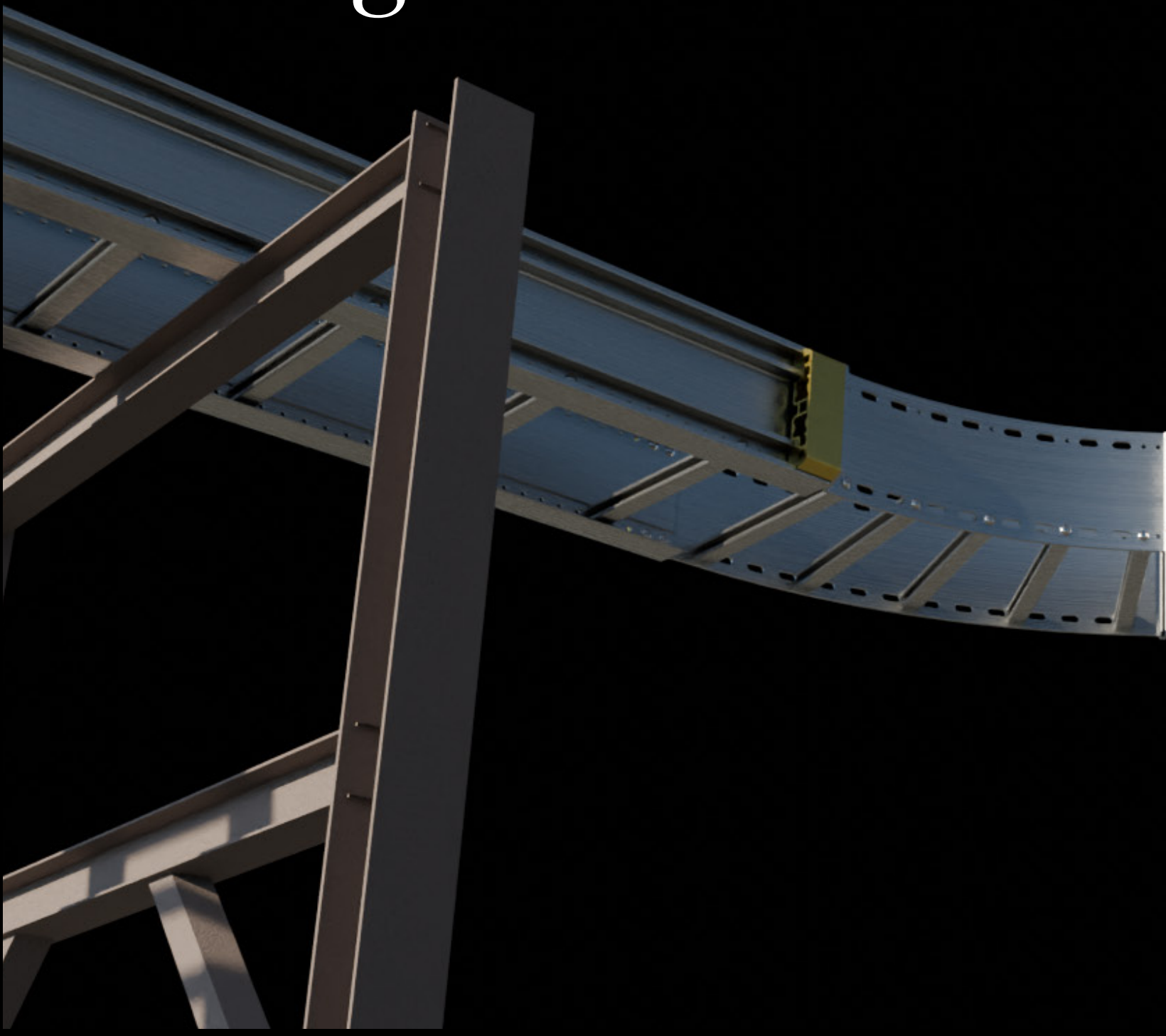
LINK @ 1/2 Span

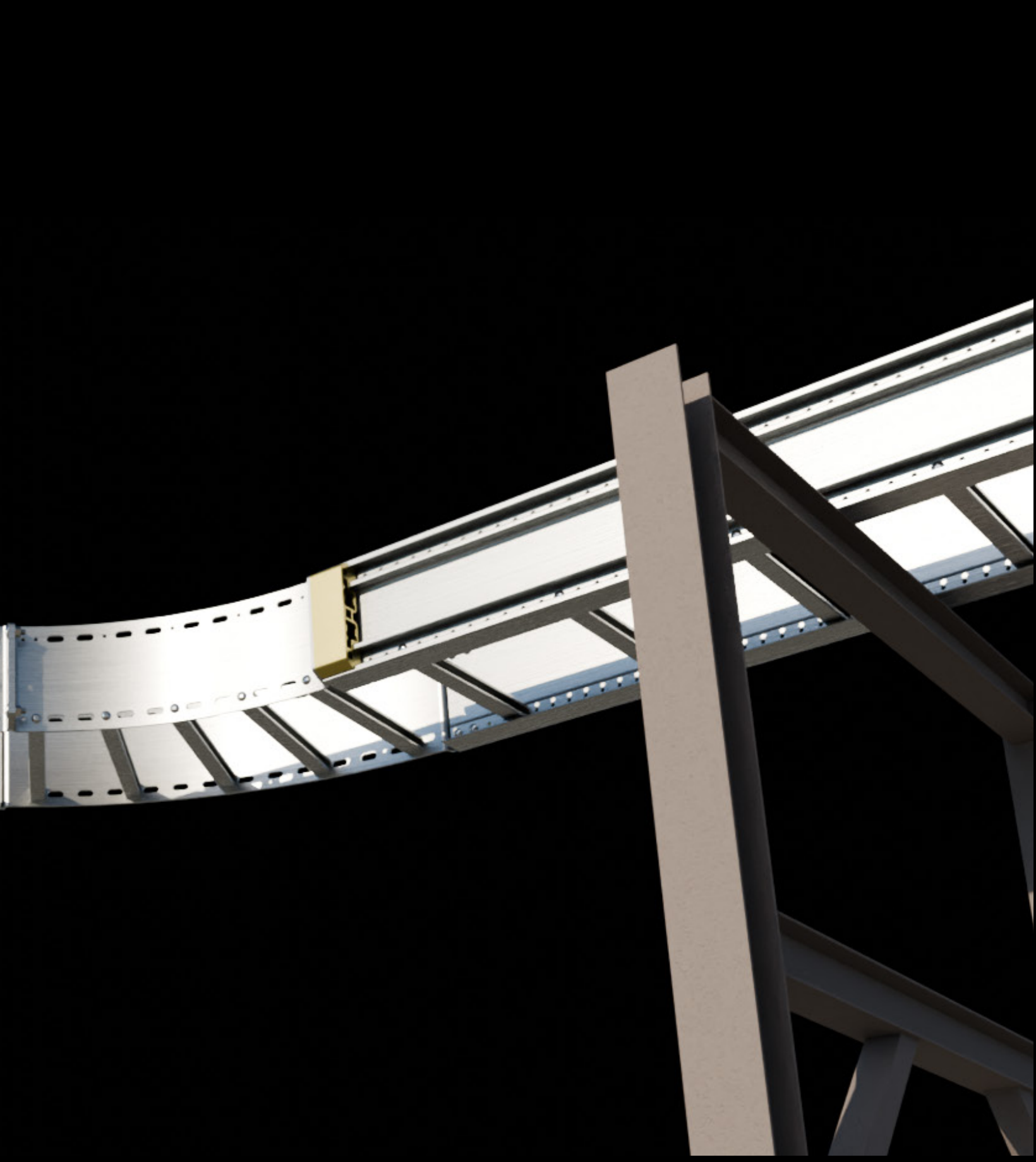


LINK @ 1/4 Span



Horizontal Fittings





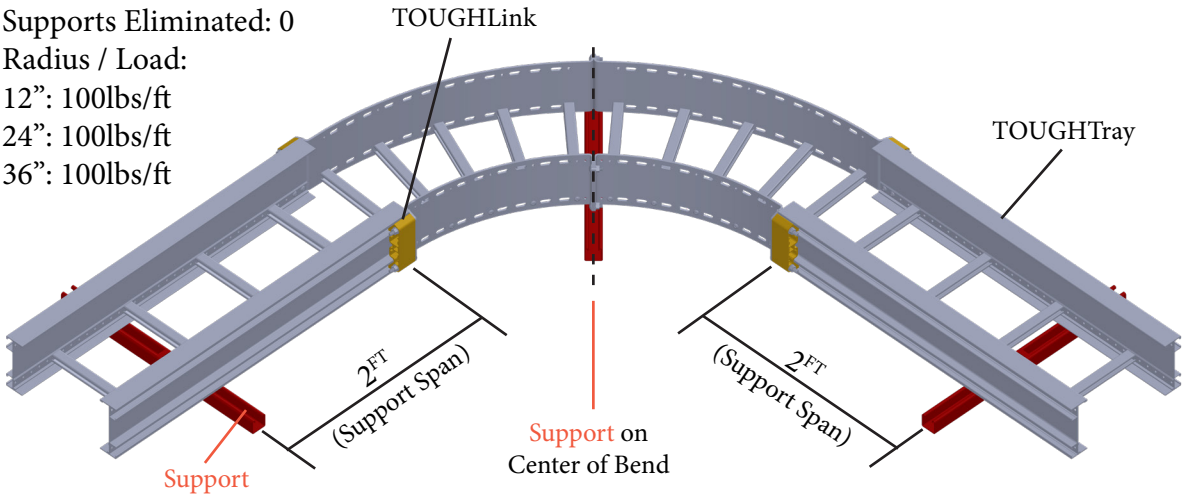
Support Location Optimization

3.1 Horizontal Bend Support Solutions:

TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.1 for horizontal bend support locations and corresponding savings values.

Figure: 3.1A

Install: **NEMA**
Supports Eliminated: 0
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



0% Design Savings

0% Installation Savings

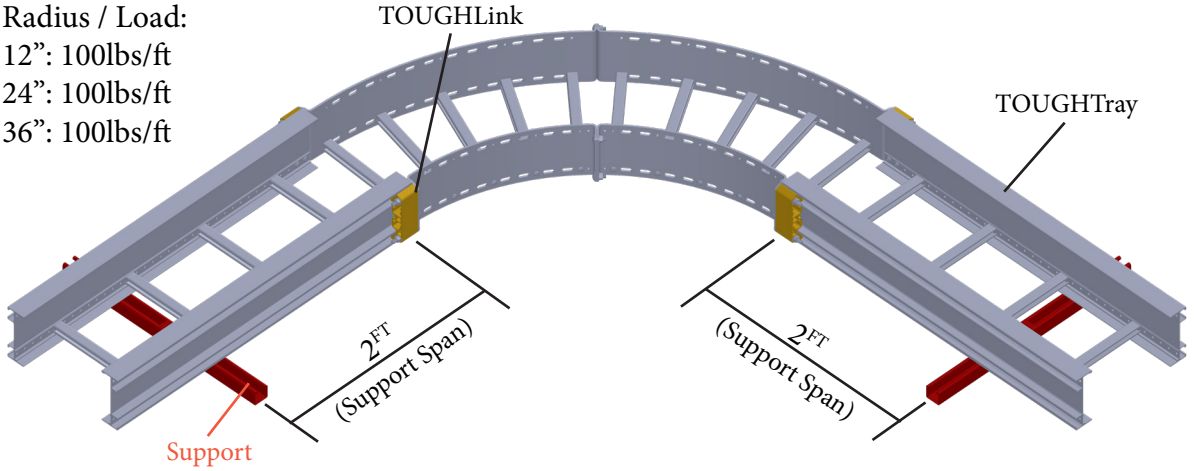
0% Material Savings

NEMA Recommendation:

- Support Directly Under Fitting
- Support Within 2FT of Fitting Union

Figure: 3.1B

Install: **Self Supporting**
Supports Eliminated: 1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



40% Design Savings

70% Installation Savings

40% Material Savings

Manufacturer Recommendation:

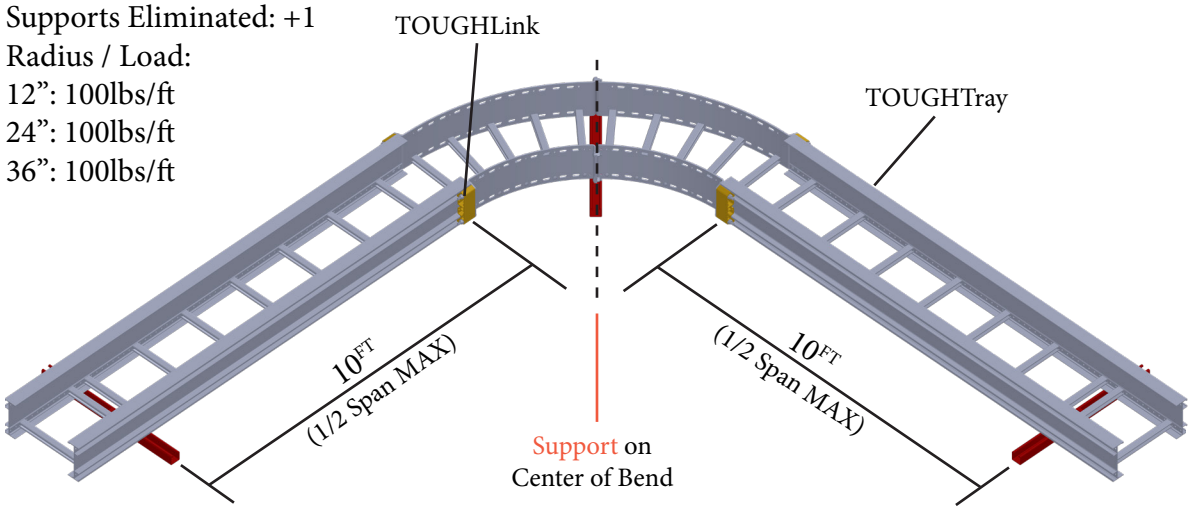
- Support Within 2FT of Fitting Union

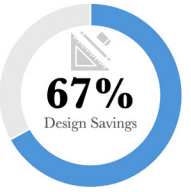
3.1 Horizontal Bend Support Solutions:

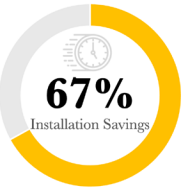
TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.1 for horizontal bend support locations and corresponding savings values.

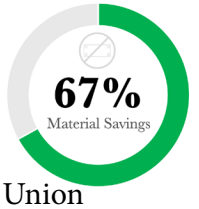
Figure: 3.1C

Install: **1/2 Span**
Supports Eliminated: +1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft







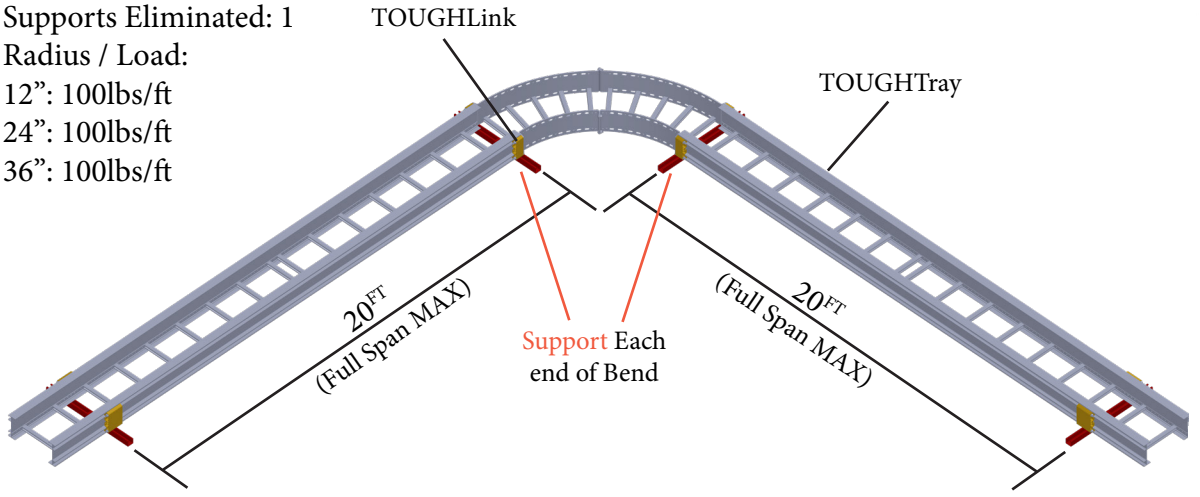


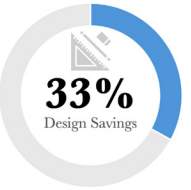
Manufacturer Recommendation:

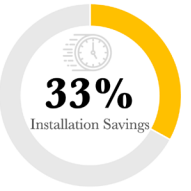
- Support Directly Under Fitting
- Support Within 1/2 Span of Fitting Union

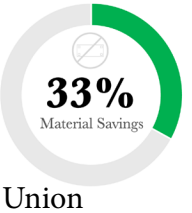
Figure: 3.1D

Install: **Full Span**
Supports Eliminated: 1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft









Manufacturer Recommendation:

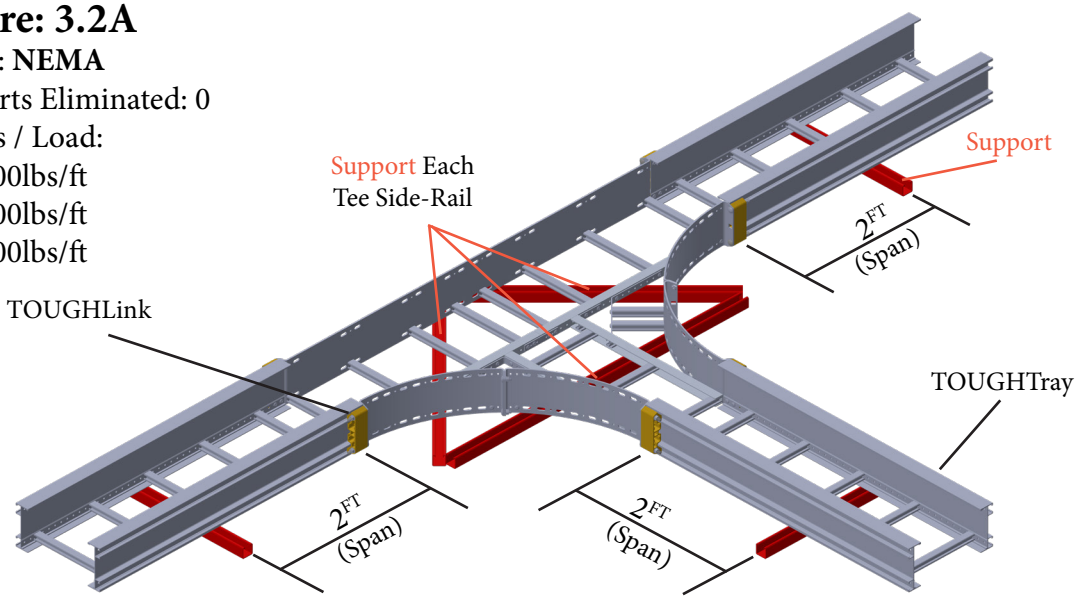
- Support Directly Under Links
- Support Within Full Span of Fitting Union

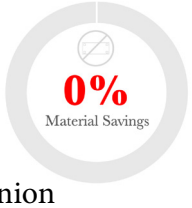
3.2 Horizontal Tee Support Solutions:

TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.2 for horizontal tee support locations and corresponding savings values.

Figure: 3.2A

Install: **NEMA**
Supports Eliminated: 0
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft





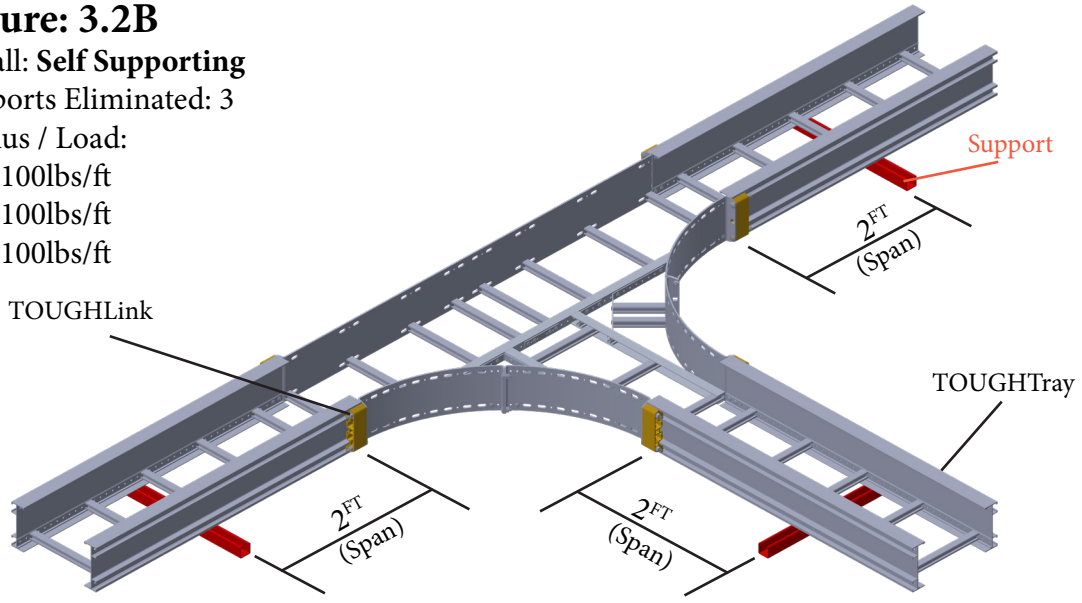
NEMA
National Electrical Manufacturers Association

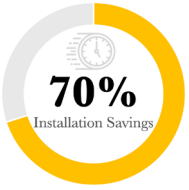
NEMA Recommendation:

- Support Directly Under Fitting
- Support Within 2FT of Fitting Union

Figure: 3.2B

Install: **Self Supporting**
Supports Eliminated: 3
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft





TOUGH SUPPORT SAVINGS

Manufacturer Recommendation:

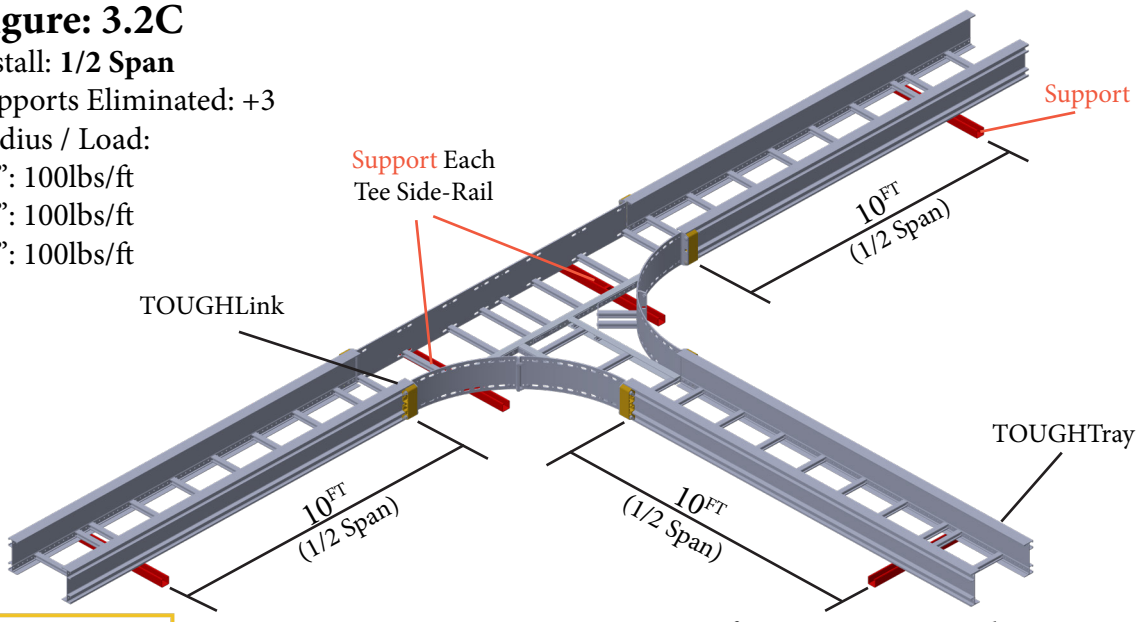
- Support Within 2FT of Fitting Union

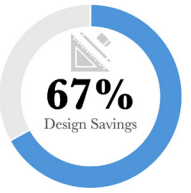
3.2 Horizontal Tee Support Solutions:

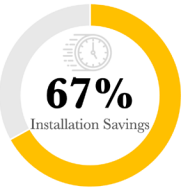
TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.2 for horizontal tee support locations and corresponding savings values.

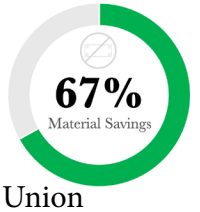
Figure: 3.2C

Install: **1/2 Span**
Supports Eliminated: +3
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft







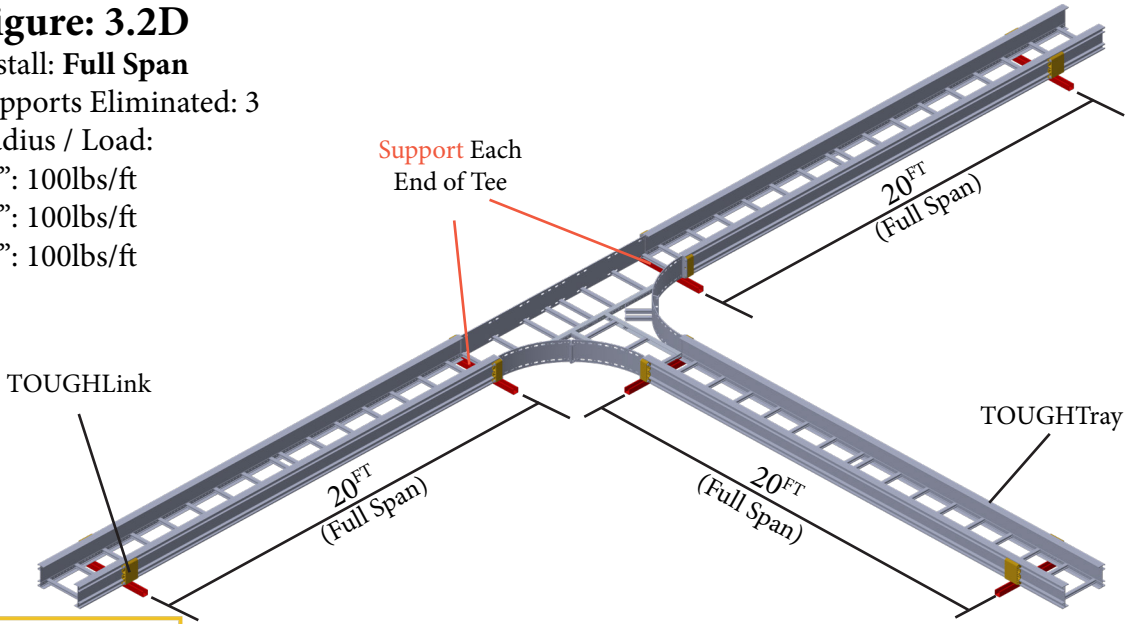


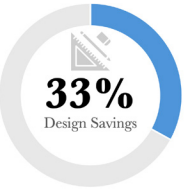
Manufacturer Recommendation:

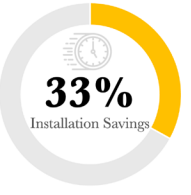
- Support Directly Under Fitting
- Support Within 1/2 Span of Fitting Union

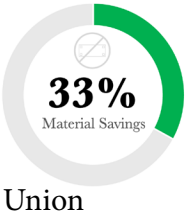
Figure: 3.2D

Install: **Full Span**
Supports Eliminated: 3
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft









Manufacturer Recommendation:

- Support Directly Under Links
- Support Within Full Span of Fitting Union

Section 3: Fittings

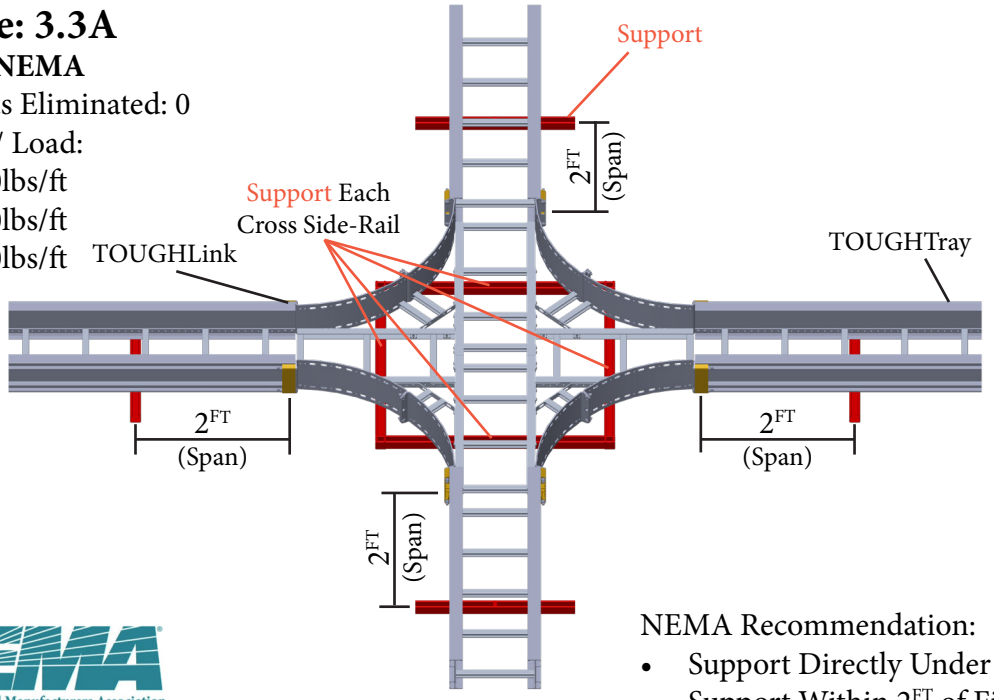
3.2 Horizontal Cross

3.3 Horizontal Cross Support Solutions:

TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.3 for horizontal cross support locations and corresponding savings values.

Figure: 3.3A

Install: **NEMA**
Supports Eliminated: 0
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft

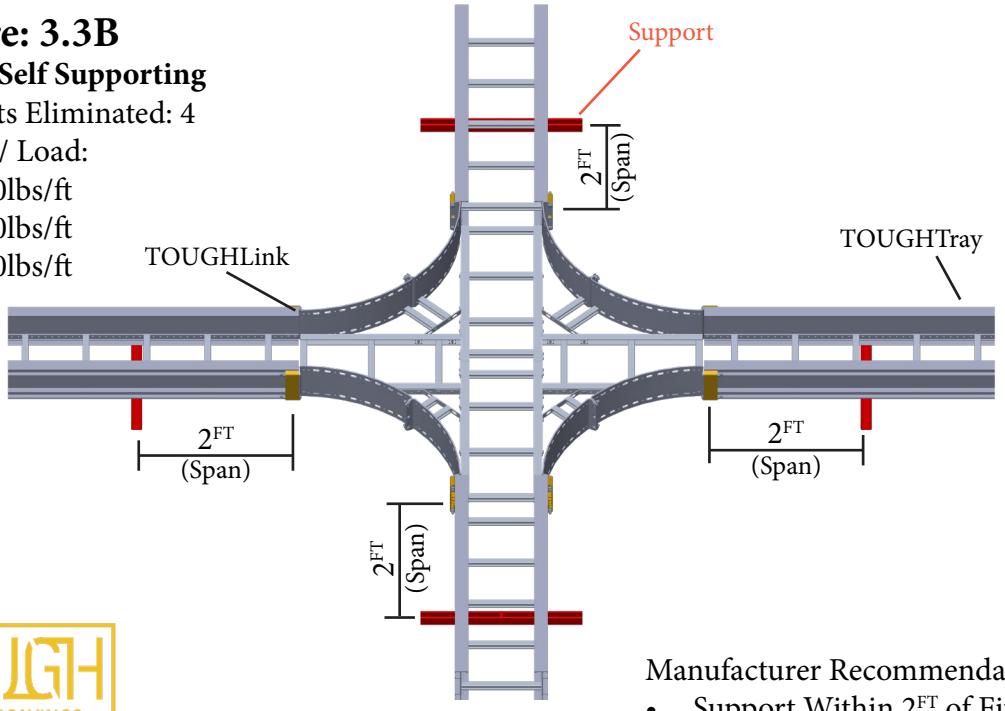


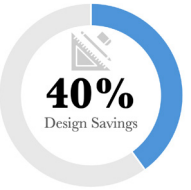
NEMA Recommendation:

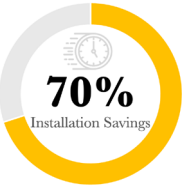
- Support Directly Under Fitting
- Support Within 2FT of Fitting Union

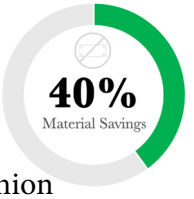
Figure: 3.3B

Install: **Self Supporting**
Supports Eliminated: 4
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft









Manufacturer Recommendation:

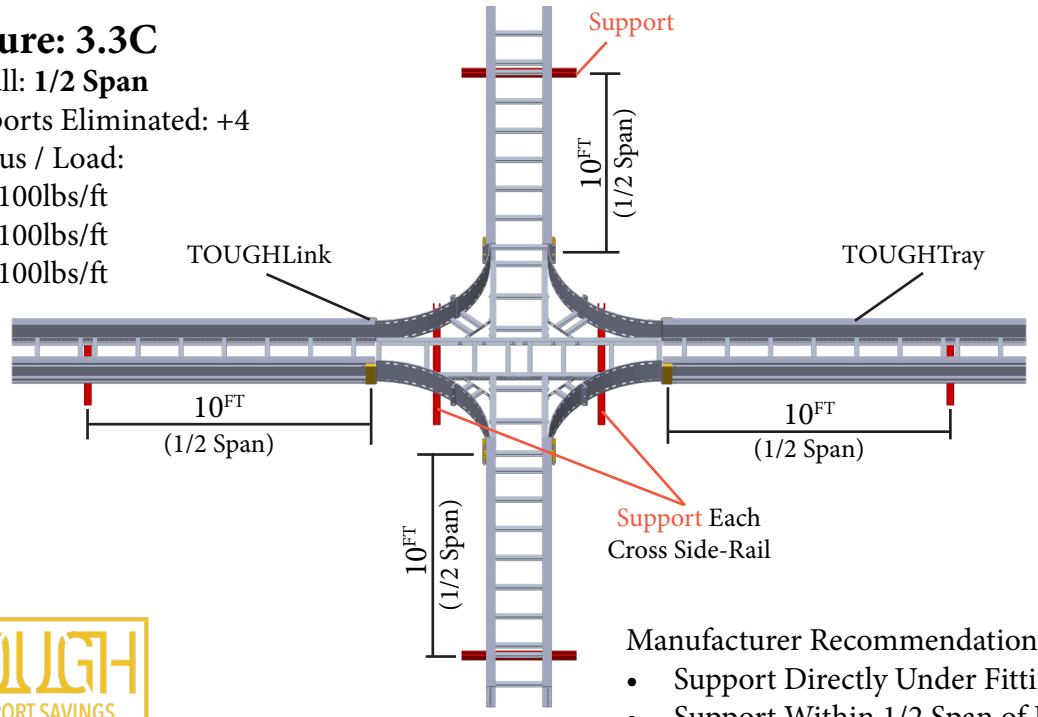
- Support Within 2FT of Fitting Union

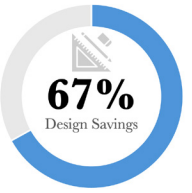
3.3 Horizontal Cross Support Solutions:

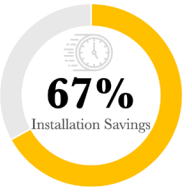
TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-3.3 for horizontal cross support locations and corresponding savings values.

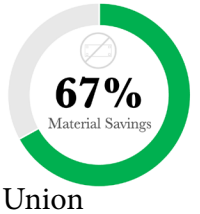
Figure: 3.3C

Install: **1/2 Span**
Supports Eliminated: +4
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft







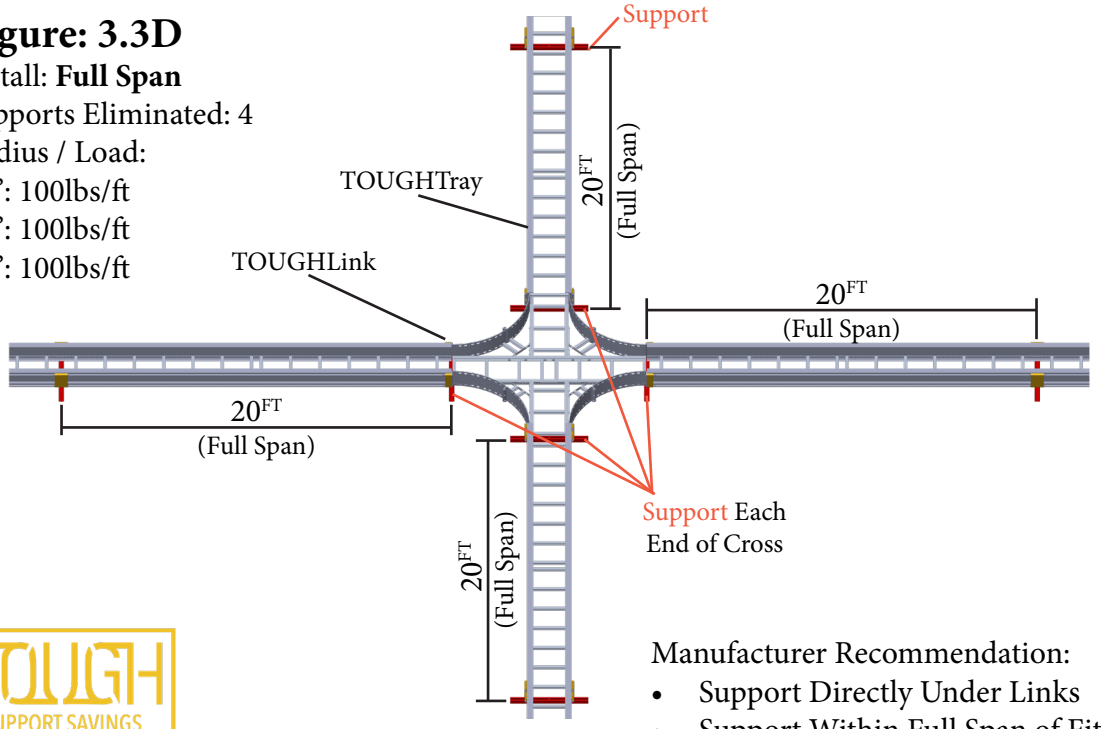


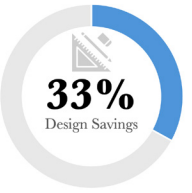
Manufacturer Recommendation:

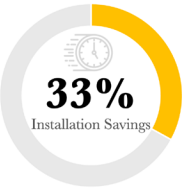
- Support Directly Under Fitting
- Support Within 1/2 Span of Fitting Union

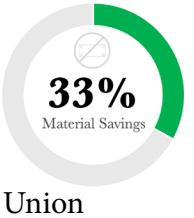
Figure: 3.3D

Install: **Full Span**
Supports Eliminated: 4
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft





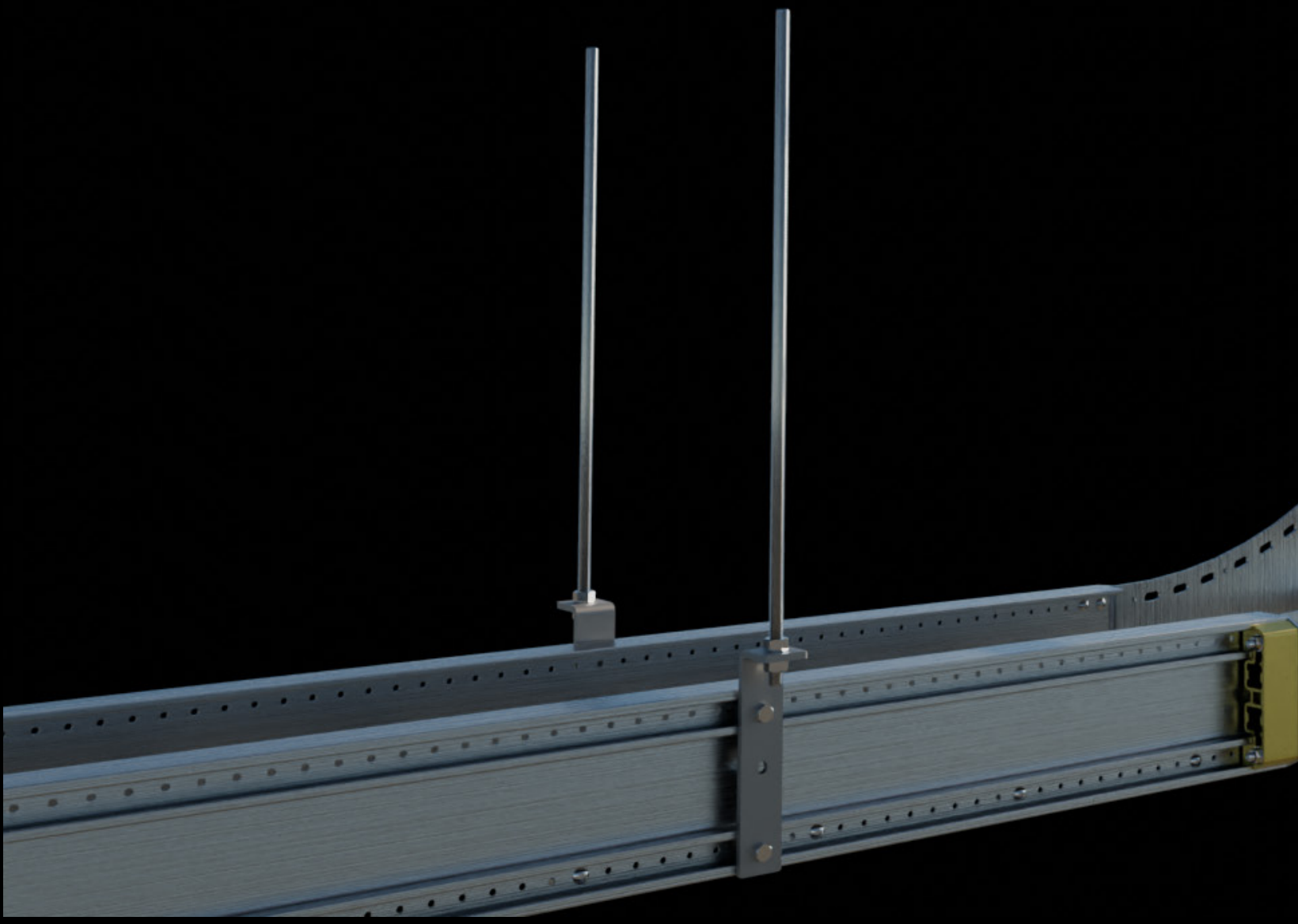


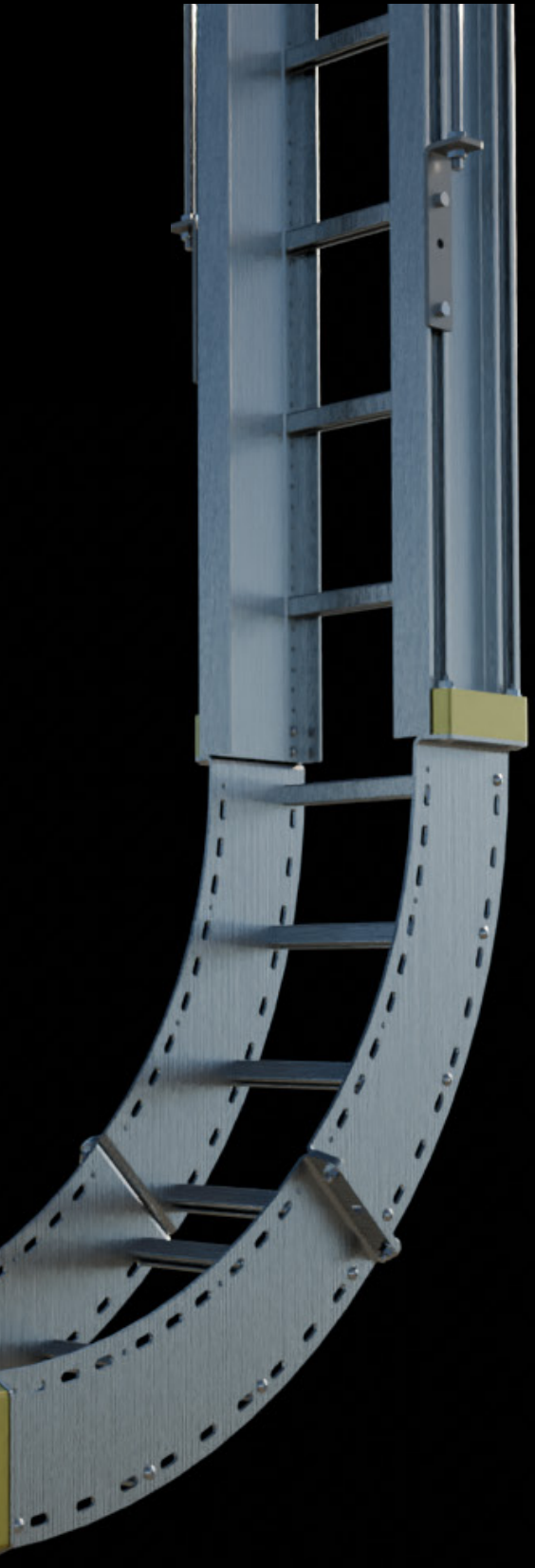


Manufacturer Recommendation:

- Support Directly Under Links
- Support Within Full Span of Fitting Union

Vertical Fittings



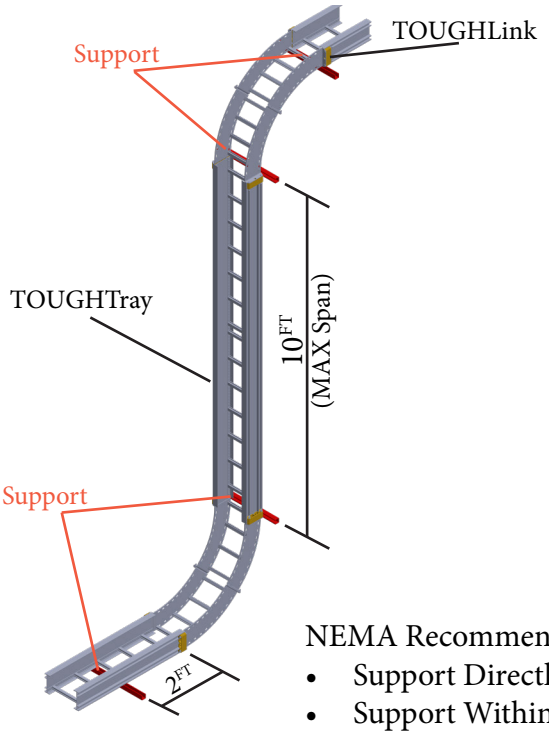


Support Location
Optimization

4.1 Vertical Bend Support Solutions:

Manufacturer Recommendations are given to reduce structural support design complexity and materials. Optimization is achieved by designing supports in the most efficient structural location and minimizing the support quantity. Recommendations with corresponding savings values are detailed in Section-4.1.

Figure: 4.1A
Install: **NEMA**
Supports Eliminated: 0
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



0% Design Savings

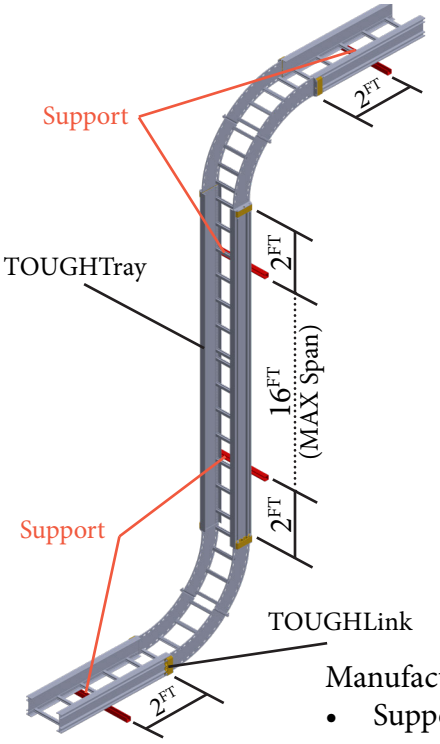
0% Installation Savings

0% Material Savings

NEMA Recommendation:

- Support Directly Under Fittings
- Support Within 2FT of Fitting Union

Figure: 4.1B
Install: **Self Supporting**
Supports Eliminated: 1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



30% Design Savings

20% Installation Savings

20% Material Savings

Manufacturer Recommendation:

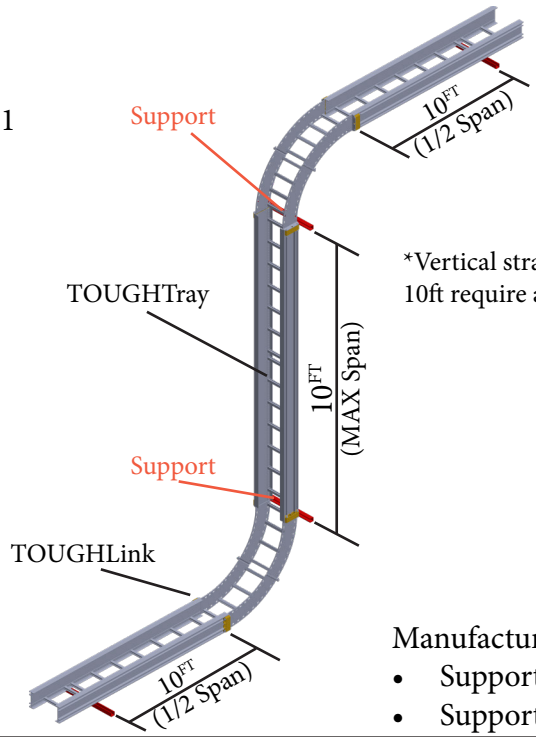
- Support Within 2FT of Fitting Union

4.1 Vertical Bend Support Solutions:

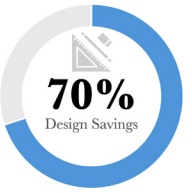
Manufacturer Recommendations are given to reduce structural support design complexity and materials. Optimization is achieved by designing supports in the most efficient structural location and minimizing the support quantity. Recommendations with corresponding savings values are detailed in Section-4.1.

Figure: 4.1C

Install: **1/2 Span**
Supports Eliminated: +1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



*Vertical straight sections greater than 10ft require at least 1 support per section.

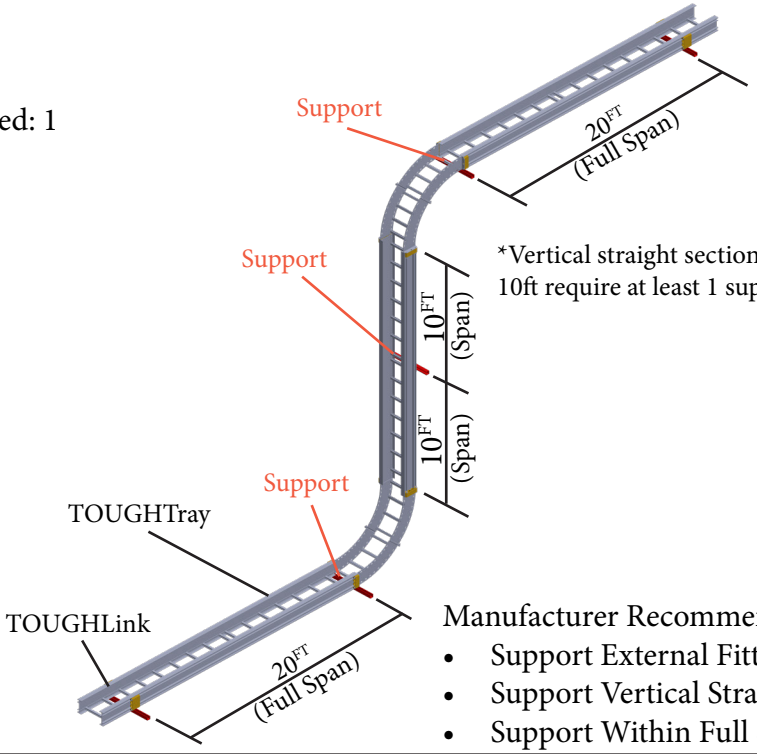


Manufacturer Recommendation:

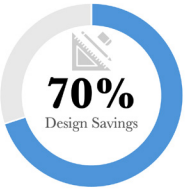
- Support Internal Fitting Links
- Support Within 1/2 Span of Fitting Union

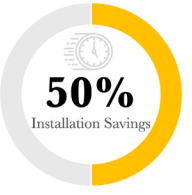
Figure: 4.1D

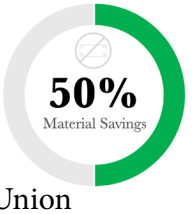
Install: **Full Span**
Supports Eliminated: 1
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



*Vertical straight sections greater than 10ft require at least 1 support per section.



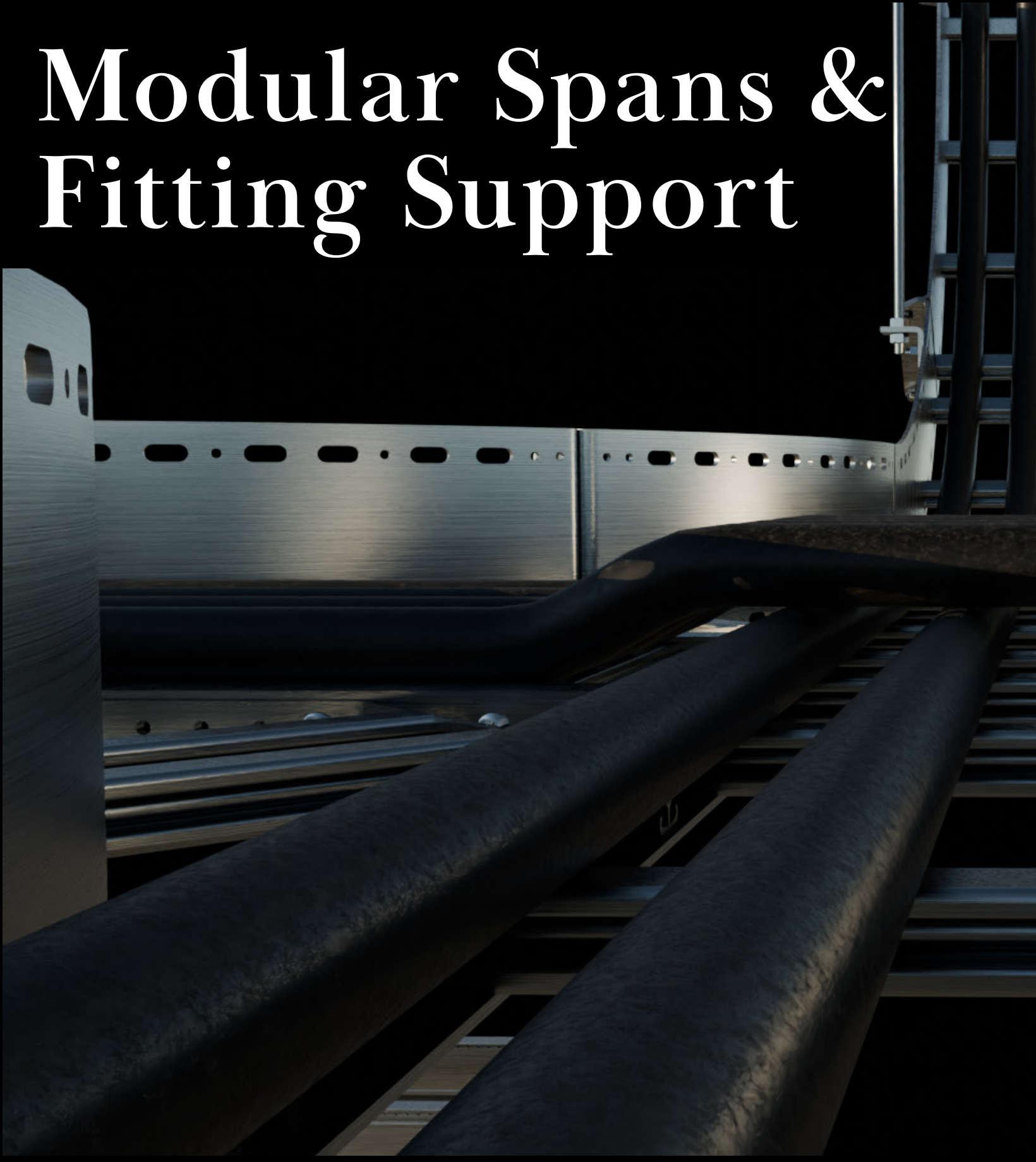


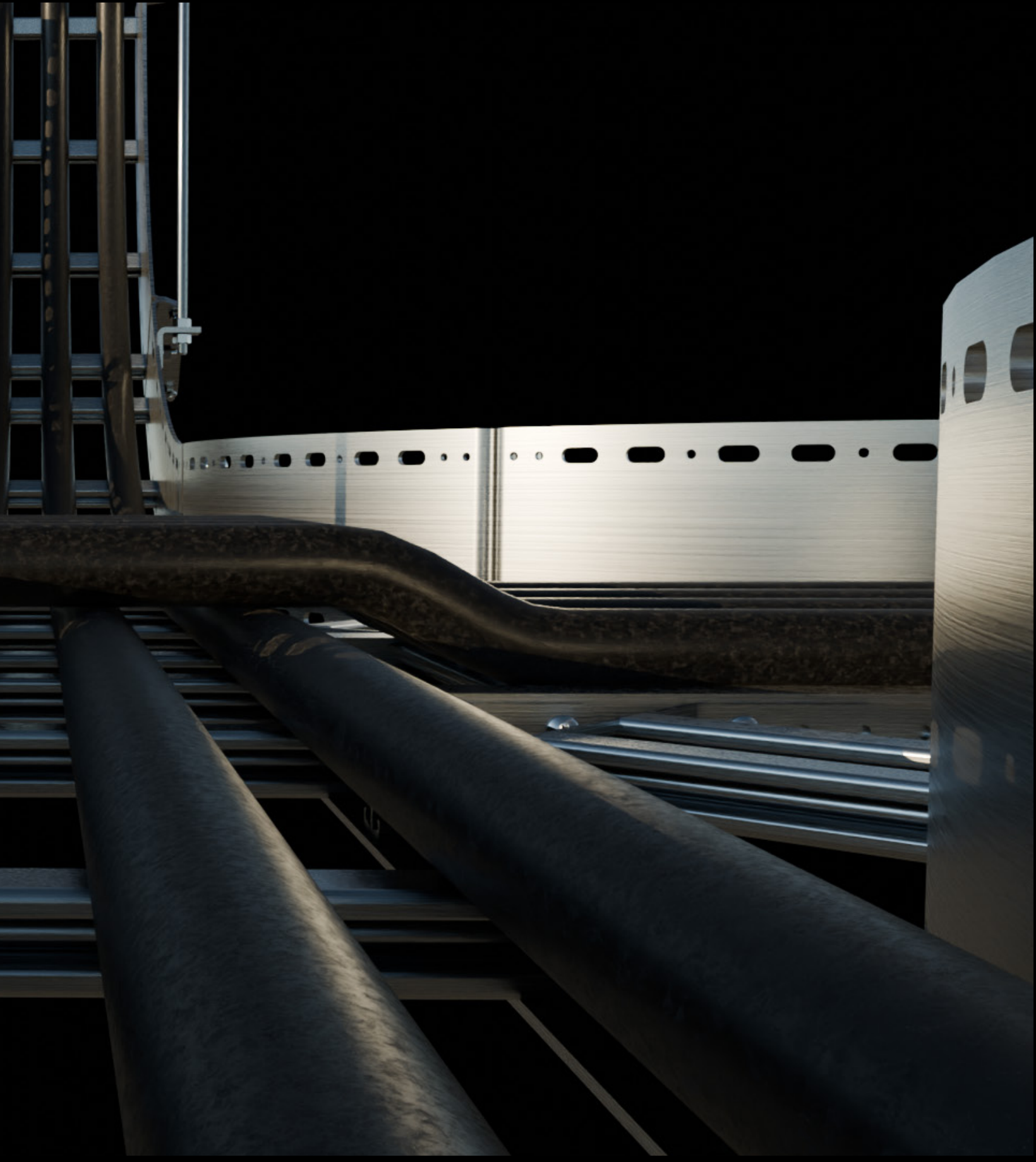


Manufacturer Recommendation:

- Support External Fitting Links
- Support Vertical Straight at Midspan
- Support Within Full Span of Fitting Union

Modular Spans & Fitting Support



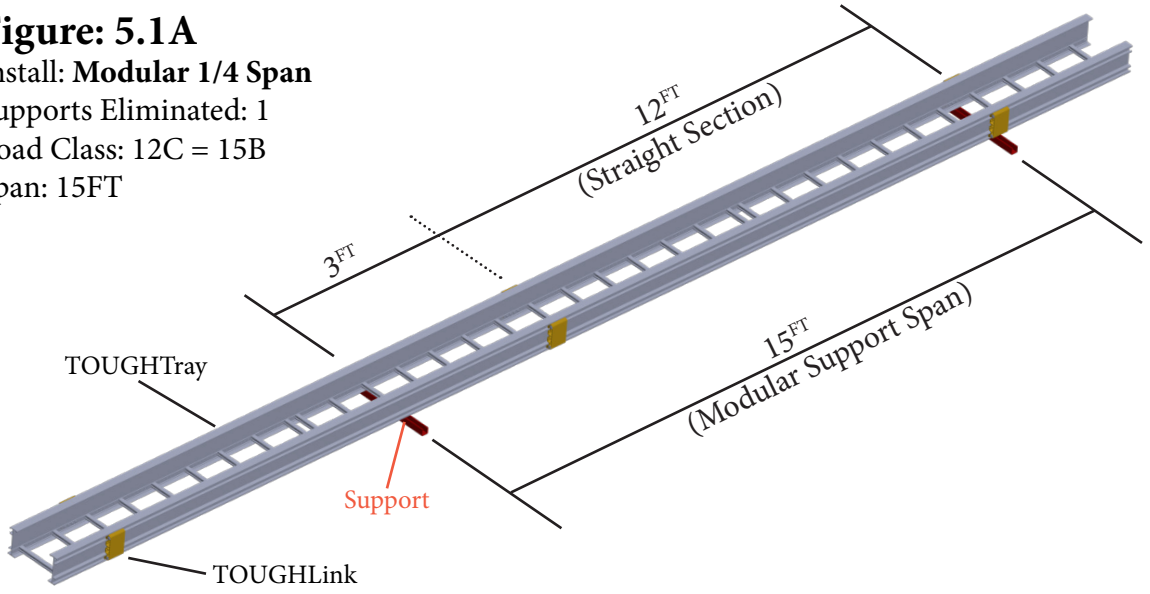


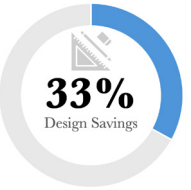
Support Location
Optimization

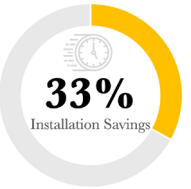
5.1 Horizontal Modular Support Solutions: 12FT

Interchangeable components and link connectivity delivers a comprehensive portfolio of industry leading tray application and support solutions. Modularity that is focused on greater design flexibility, construction efficiency and installation connectivity.

Figure: 5.1A
Install: **Modular 1/4 Span**
Supports Eliminated: 1
Load Class: 12C = 15B
Span: 15FT

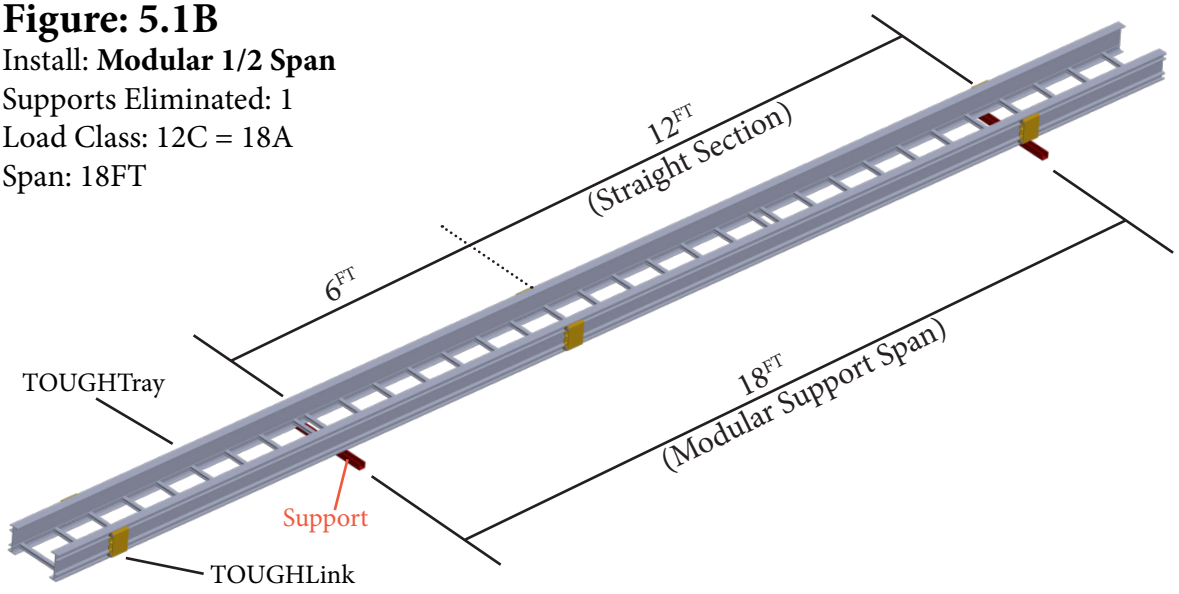


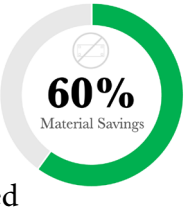




Manufacturer Recommendation:
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.1B
Install: **Modular 1/2 Span**
Supports Eliminated: 1
Load Class: 12C = 18A
Span: 18FT





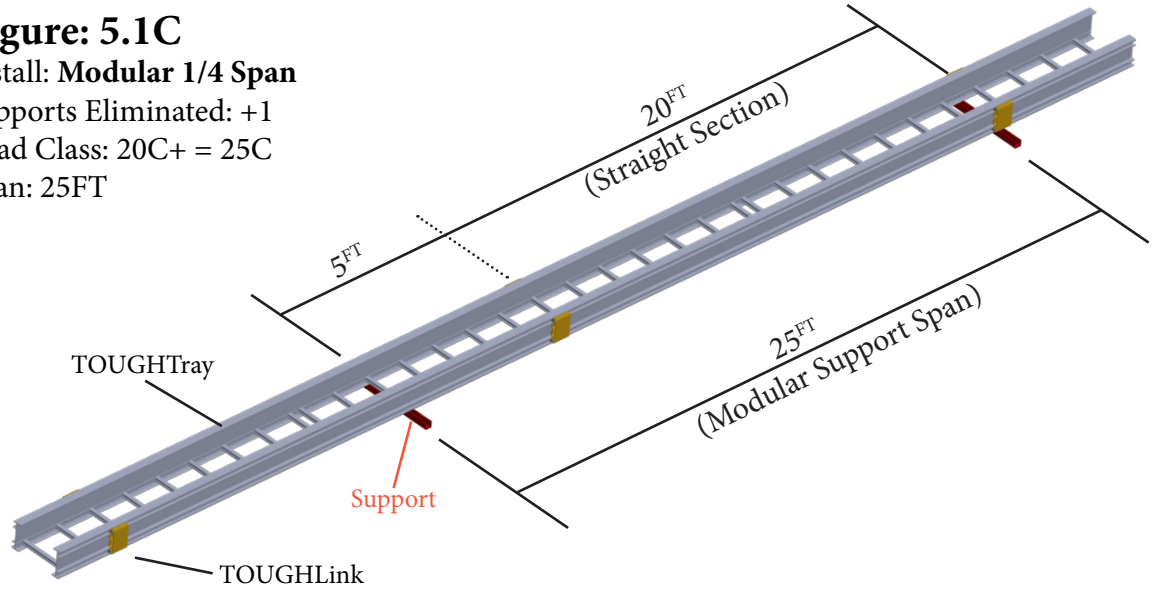
Manufacturer Recommendation:
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

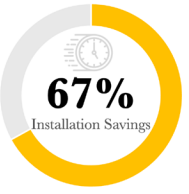
5.1 Horizontal Modular Support Solutions: 20FT

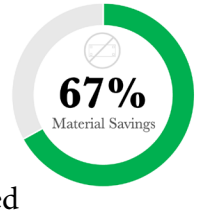
Interchangeable components and link connectivity delivers a comprehensive portfolio of industry leading tray application and support solutions. Modularity that is focused on greater design flexibility, construction efficiency and installation connectivity.

Figure: 5.1C

Install: **Modular 1/4 Span**
Supports Eliminated: +1
Load Class: 20C+ = 25C
Span: 25FT





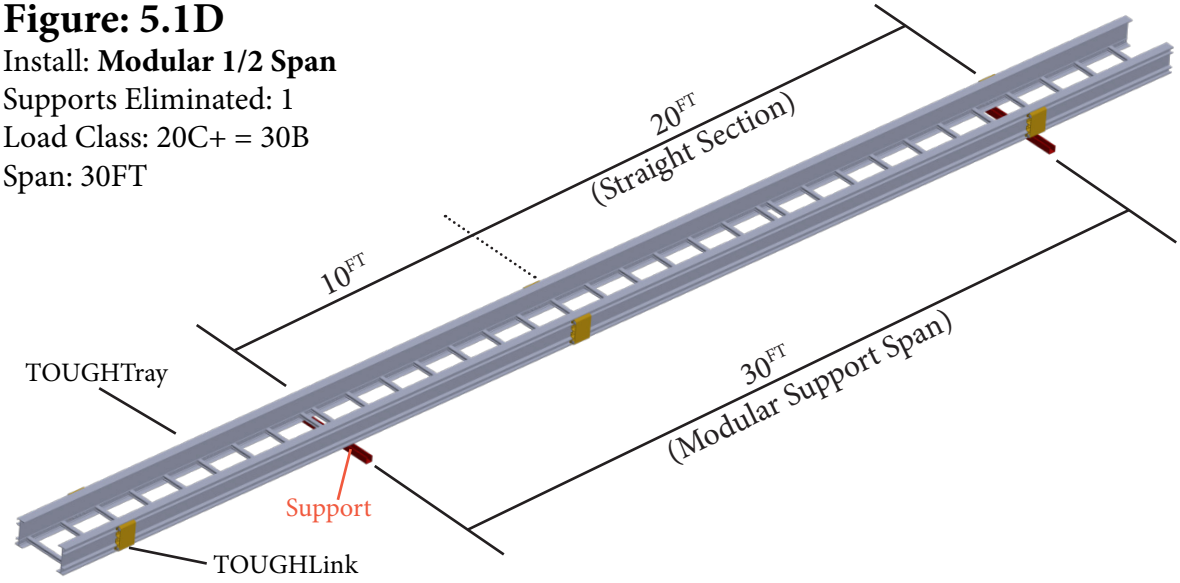


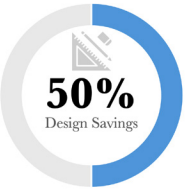
Manufacturer Recommendation:

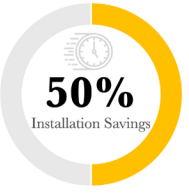
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.1D

Install: **Modular 1/2 Span**
Supports Eliminated: 1
Load Class: 20C+ = 30B
Span: 30FT







Manufacturer Recommendation:

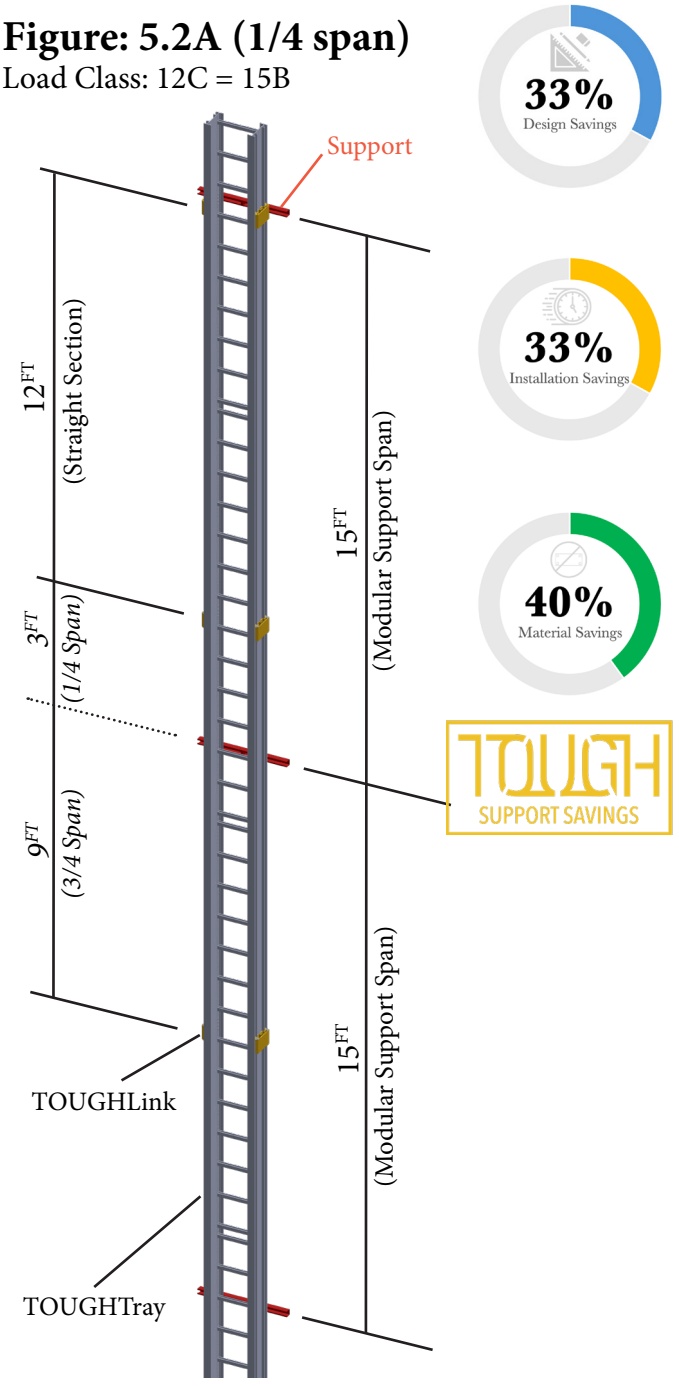
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

5.2 Vertical Modular Support Solutions: 12FT

TOUGHTray connectivity provide superior structural tray performance. Simply link the 12FT sections together to create modular spans greater than a straight section length.

Figure: 5.2A (1/4 span)

Load Class: 12C = 15B

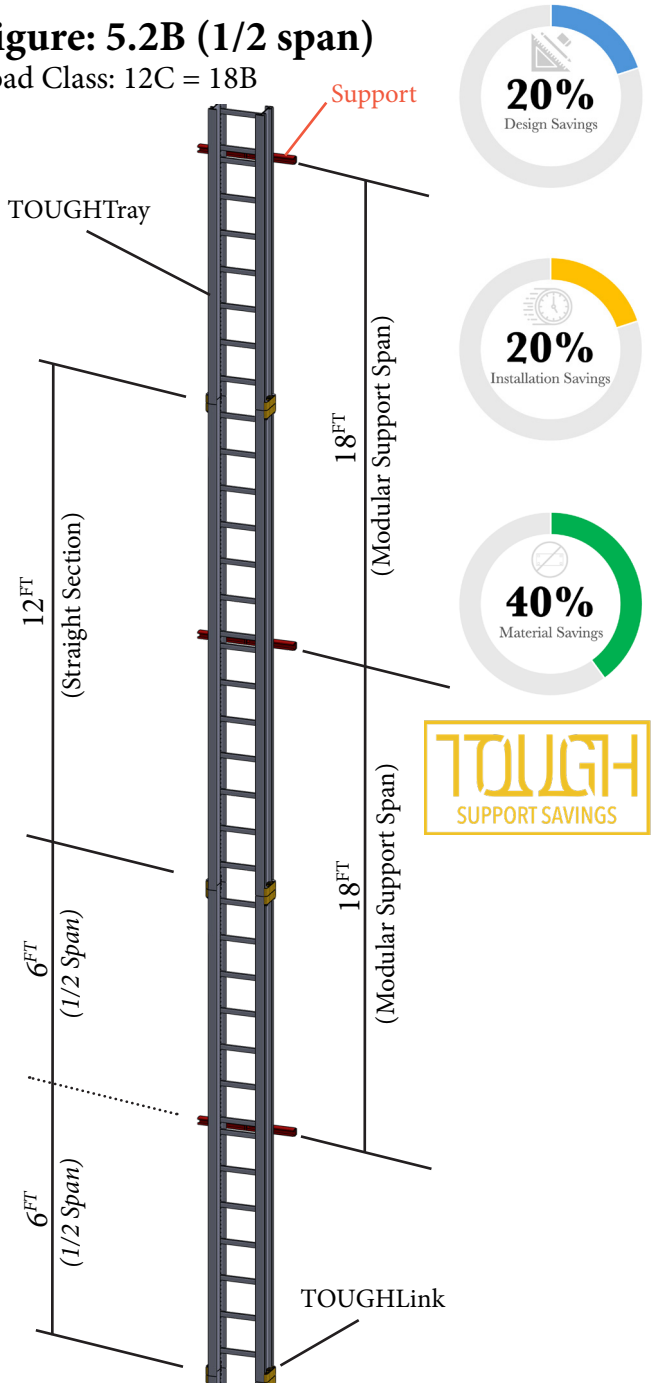


Manufacturer Recommendation:

- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.2B (1/2 span)

Load Class: 12C = 18B



Manufacturer Recommendation:

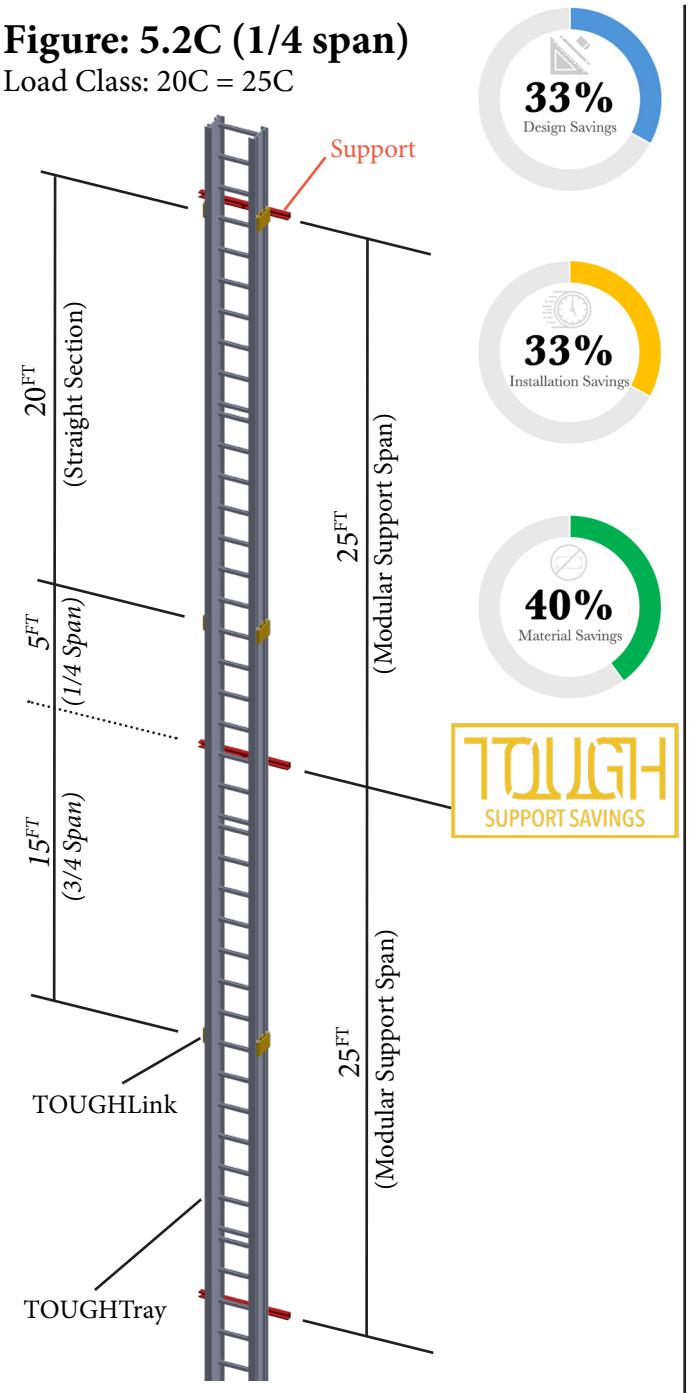
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

5.2 Vertical Modular Support Solutions: 20FT

TOUGHTray connectivity provide superior structural tray performance. Simply link the 20FT sections together to create modular spans greater than a straight section length.

Figure: 5.2C (1/4 span)

Load Class: 20C = 25C

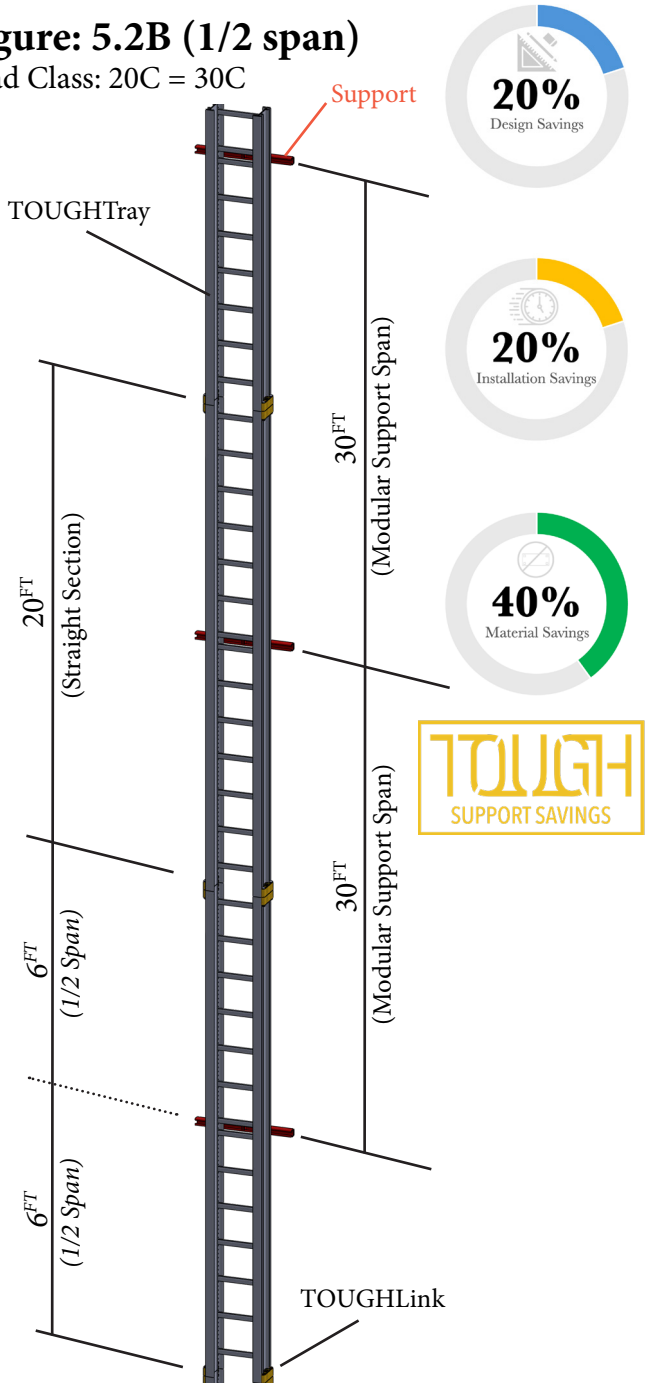


Manufacturer Recommendation:

- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.2B (1/2 span)

Load Class: 20C = 30C



Manufacturer Recommendation:

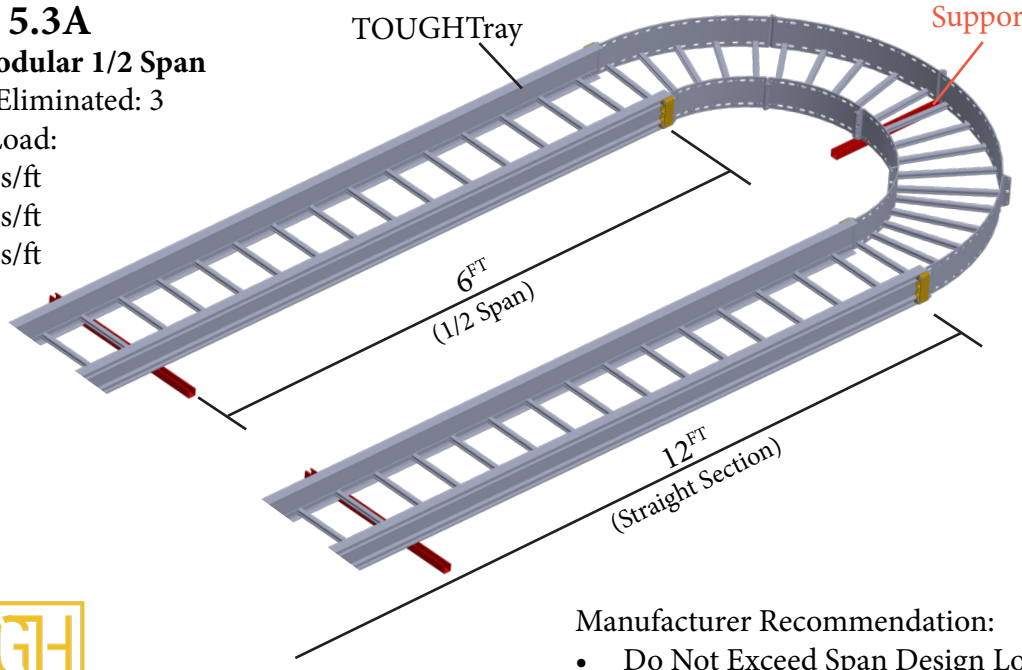
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

5.3 Horizontal Modular Bend Support Solutions:

Modular Fittings are engineered with reinforced stress points and incorporate INTEGRAL-Links. Delivering superior design flexibility and structural optimization through a portfolio of modular angles from 30° to 180°.

Figure: 5.3A

Install: **Modular 1/2 Span**
Supports Eliminated: 3
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft

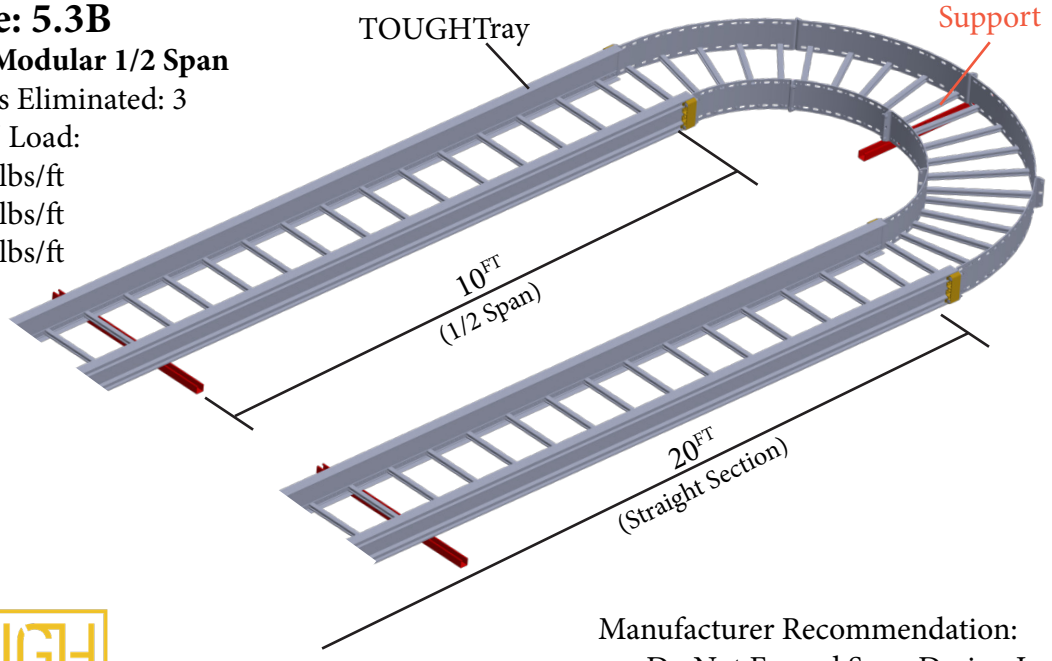


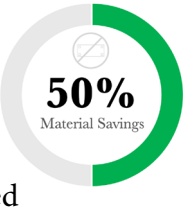
Manufacturer Recommendation:

- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.3B

Install: **Modular 1/2 Span**
Supports Eliminated: 3
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft





Manufacturer Recommendation:

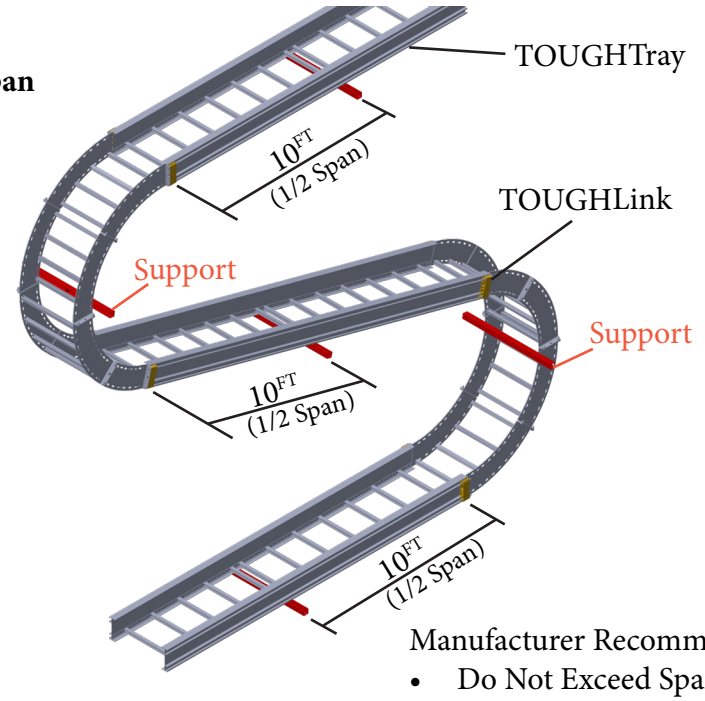
- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

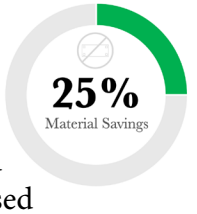
5.4 Horizontal Modular Bend Support Solutions:

Modular Fittings are engineered with reinforced stress points and incorporate INTEGRAL-Links. Delivering superior design flexibility and structural optimization through a portfolio of modular angles from 30° to 180°.

Figure: 5.4A

Install: **Modular 1/2 Span**
Supports Eliminated: 4
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft



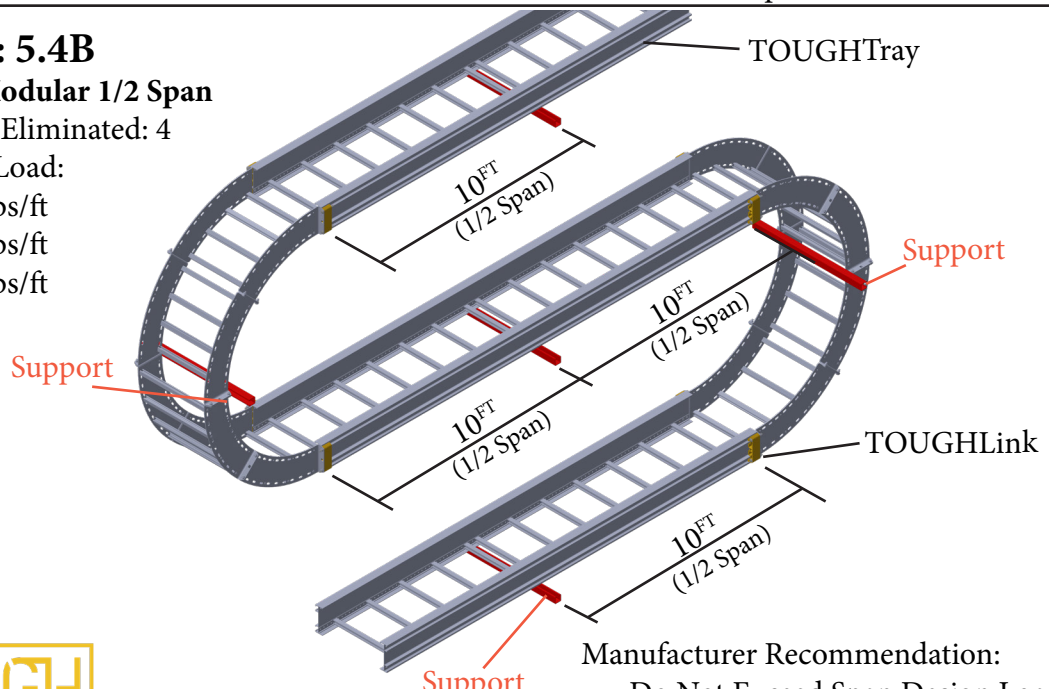


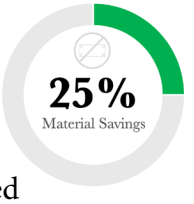
Manufacturer Recommendation:

- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Figure: 5.4B

Install: **Modular 1/2 Span**
Supports Eliminated: 4
Radius / Load:
12": 100lbs/ft
24": 100lbs/ft
36": 100lbs/ft

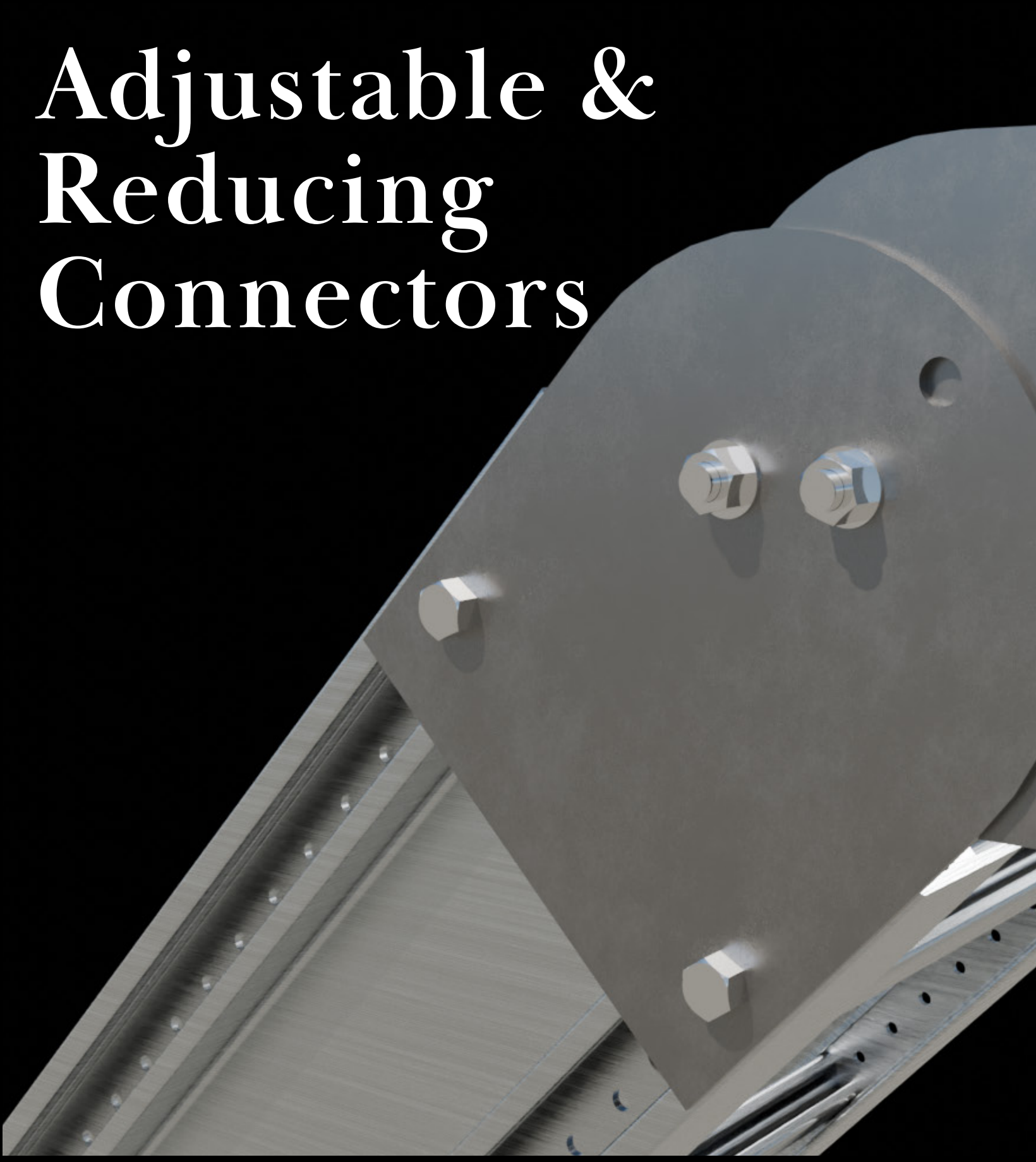


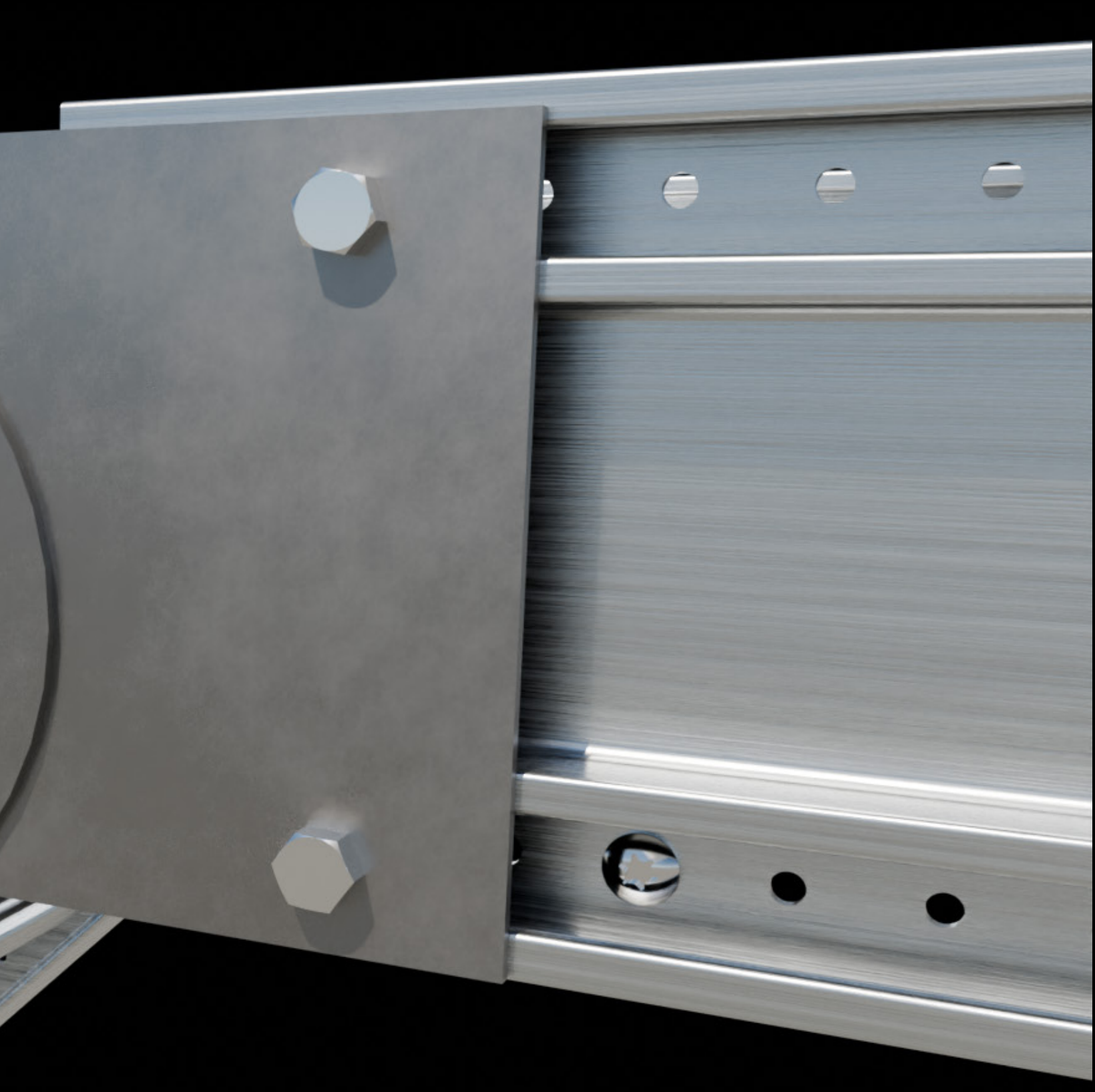


Manufacturer Recommendation:

- Do Not Exceed Span Design Load
- HD Clamps & Guides Must Be Used

Adjustable & Reducing Connectors





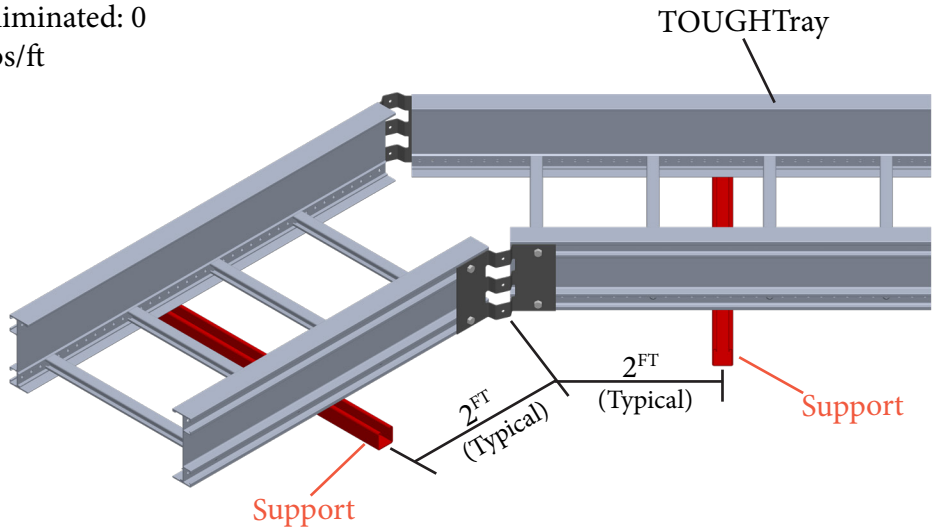
Vertical & Horizontal Recommendations

6.1 Horizontal Adjustable Support Solutions:

Manufacturer Recommendations are provided to reduce design complexity and support quantities. Optimization is achieved by designing the minimum number of supports in the most efficient location.

Figure: 6.1A

Install: **NEMA**
Supports Eliminated: 0
Load: 100lbs/ft



0% Design Savings

0% Installation Savings

0% Material Savings

NEMA
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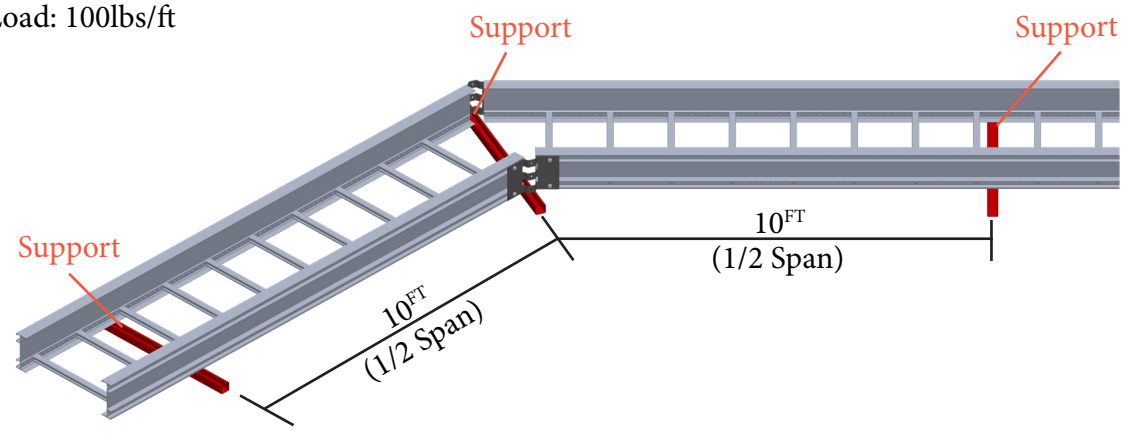
NEMA Recommendation:

- Support Within 2FT of Union

Figure: 6.1B

Install: **1/2 Span**
Supports Eliminated: 1
Load: 100lbs/ft



50% Design Savings

50% Installation Savings

50% Material Savings

TOUGH SUPPORT SAVINGS

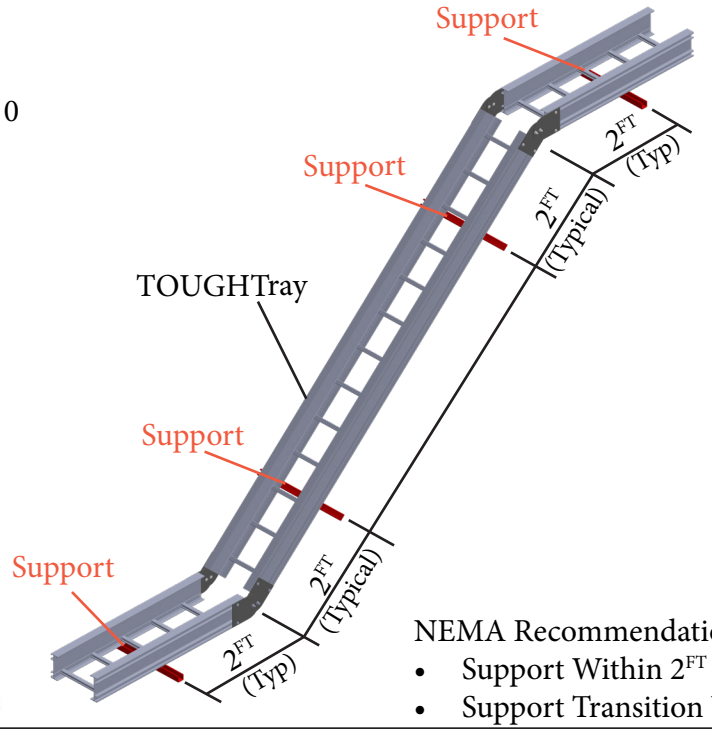
Manufacturer Recommendation:

- Support Adjustable Union
- Support Within 1/2 Span of Union

6.2 Vertical Adjustable Support Solutions:

Manufacturer Recommendations are provided to reduce design complexity and support quantities. Optimization is achieved by designing the minimum number of supports in the most efficient locations.

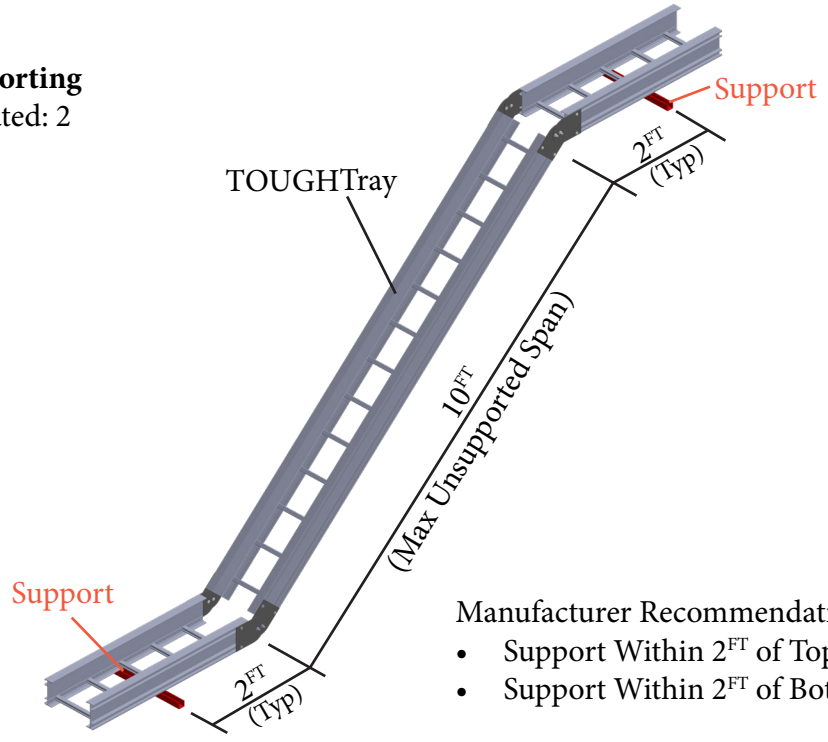
Figure: 6.2A
Install: **NEMA**
Supports Eliminated: 0
Load: 100lbs/ft



NEMA Recommendation:

- Support Within 2^{FT} of Union
- Support Transition Within 2^{FT} of Union

Figure: 6.2B
Install: **Self Supporting**
Supports Eliminated: 2
Load: 100lbs/ft



Manufacturer Recommendation:

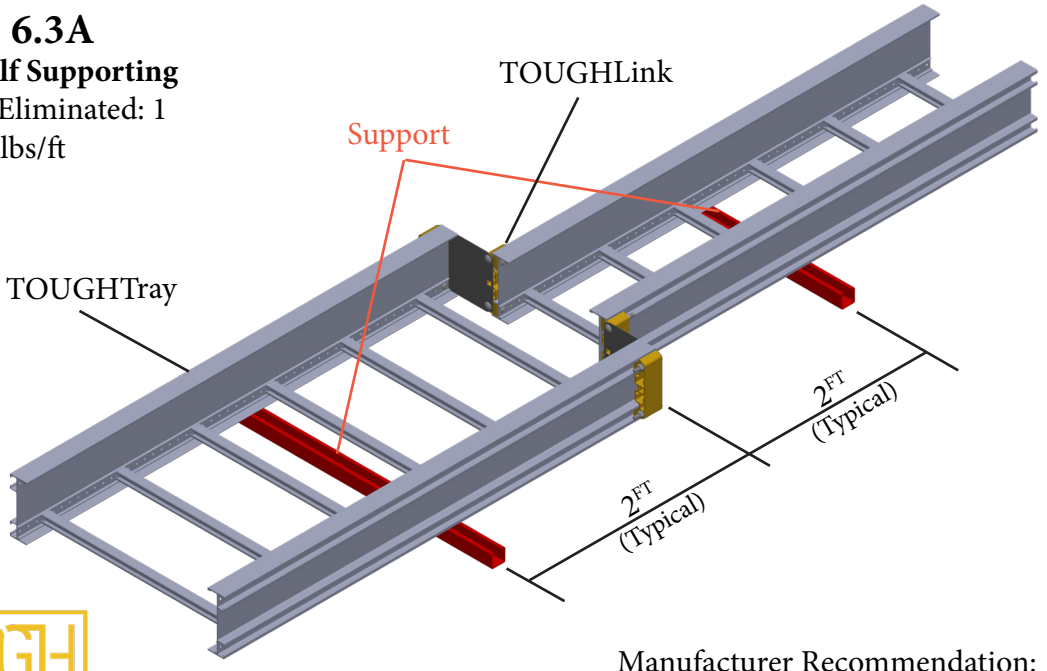
- Support Within 2^{FT} of Top Union
- Support Within 2^{FT} of Bottom Union

6.3 Reducing Plate Support Solutions:

TOUGH Support Savings for fittings is in full compliance with industry standard NEMA VE 2 Section 3.5.1 "unless otherwise recommended by the manufacturer". Manufacturer Recommendations are provided in Section-6.3 for horizontal reducer support locations with corresponding savings values.

Figure: 6.3A

Install: **Self Supporting**
Supports Eliminated: 1
Load: 100lbs/ft



0% Design Savings

50% Installation Savings

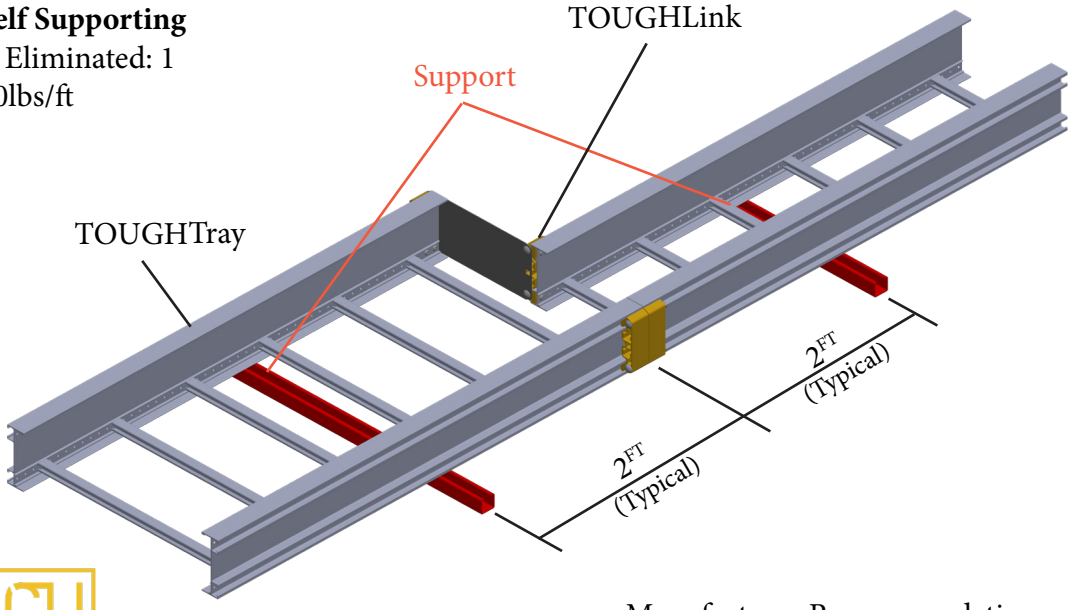
50% Material Savings

Manufacturer Recommendation:

- Support Within 2FT of Union

Figure: 6.3B

Install: **Self Supporting**
Supports Eliminated: 1
Load: 100lbs/ft



0% Design Savings

50% Installation Savings

50% Material Savings

Manufacturer Recommendation:

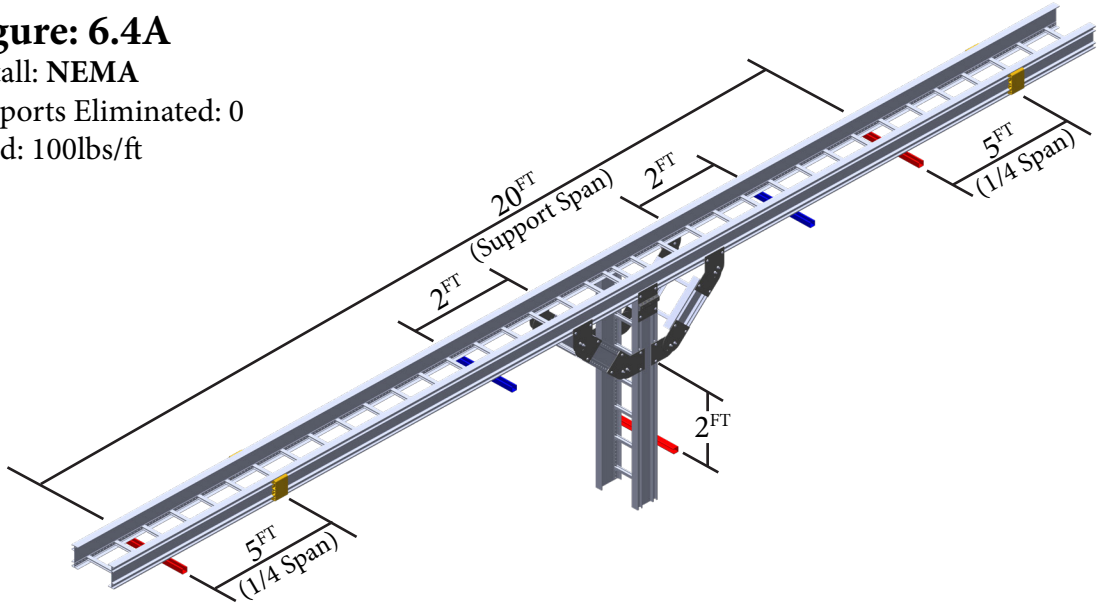
- Support Within 2FT of Union

6.4 Vertical Tee Support Solutions:

TOUGHTray modularity allows vertical sections to connect directly to horizontal sections. Tee up or down at any location within the horizontal continuous tray run using a modular tee connector kit. Manufacturer Recommendations are provided in Section 6.4 for tee support locations and corresponding savings values.

Figure: 6.4A

Install: **NEMA**
Supports Eliminated: 0
Load: 100lbs/ft



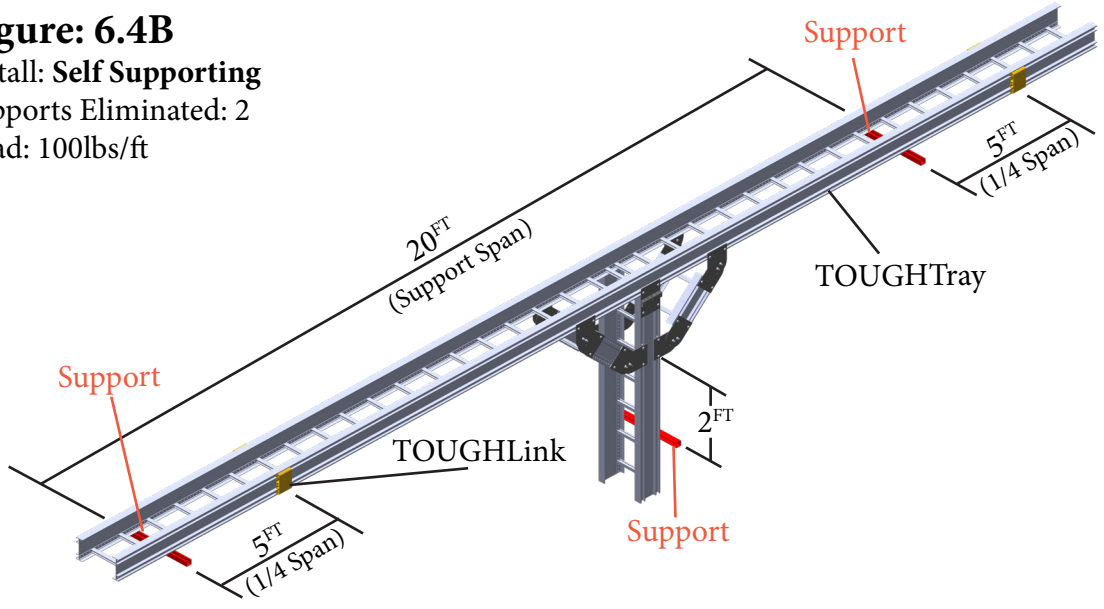
NEMA
National Electrical Manufacturers Association

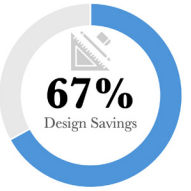
NEMA Recommendation:

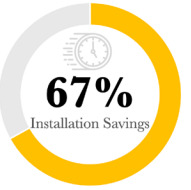
- Support Within 2^{FT} of Union

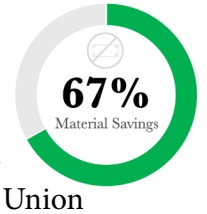
Figure: 6.4B

Install: **Self Supporting**
Supports Eliminated: 2
Load: 100lbs/ft







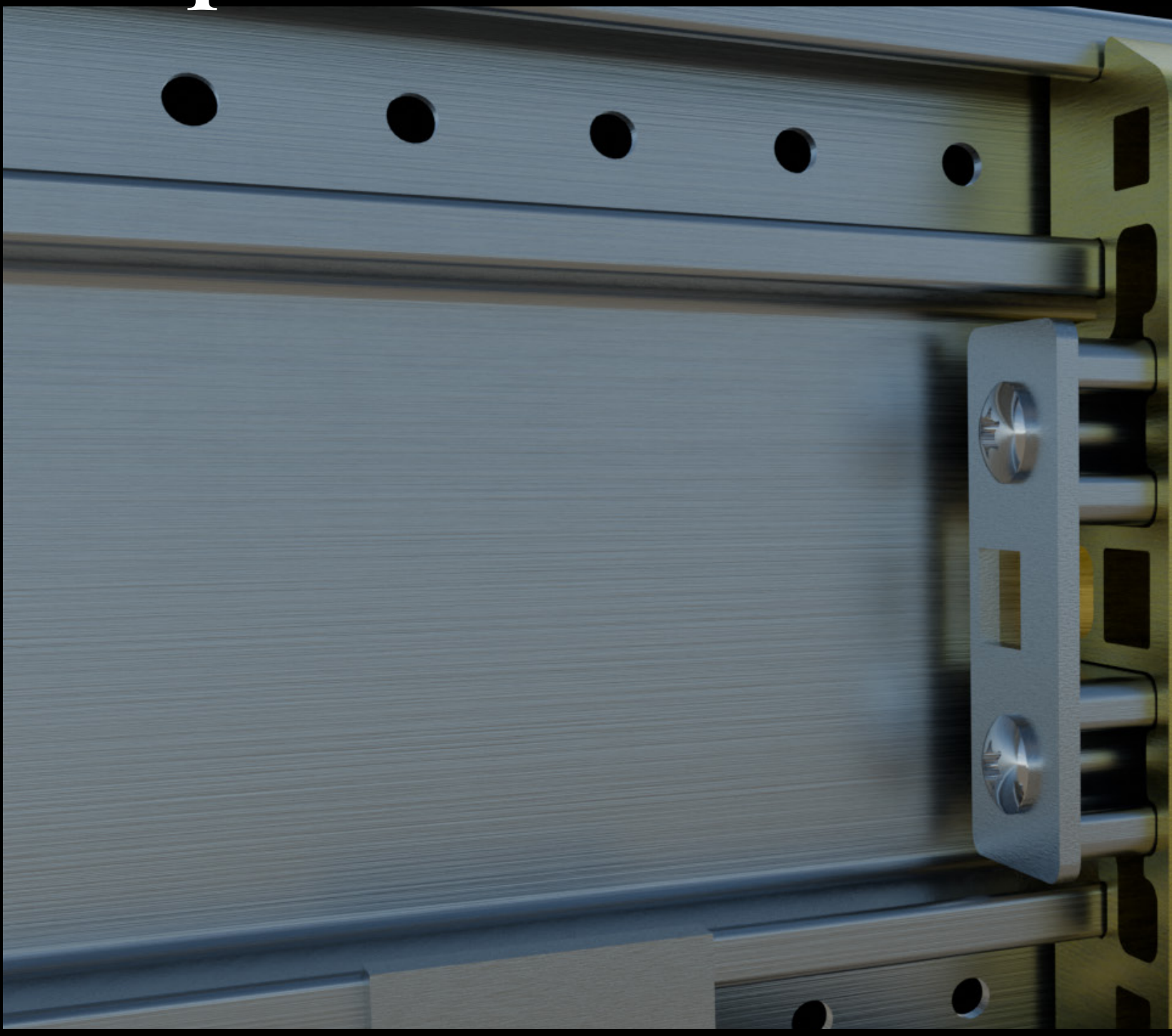


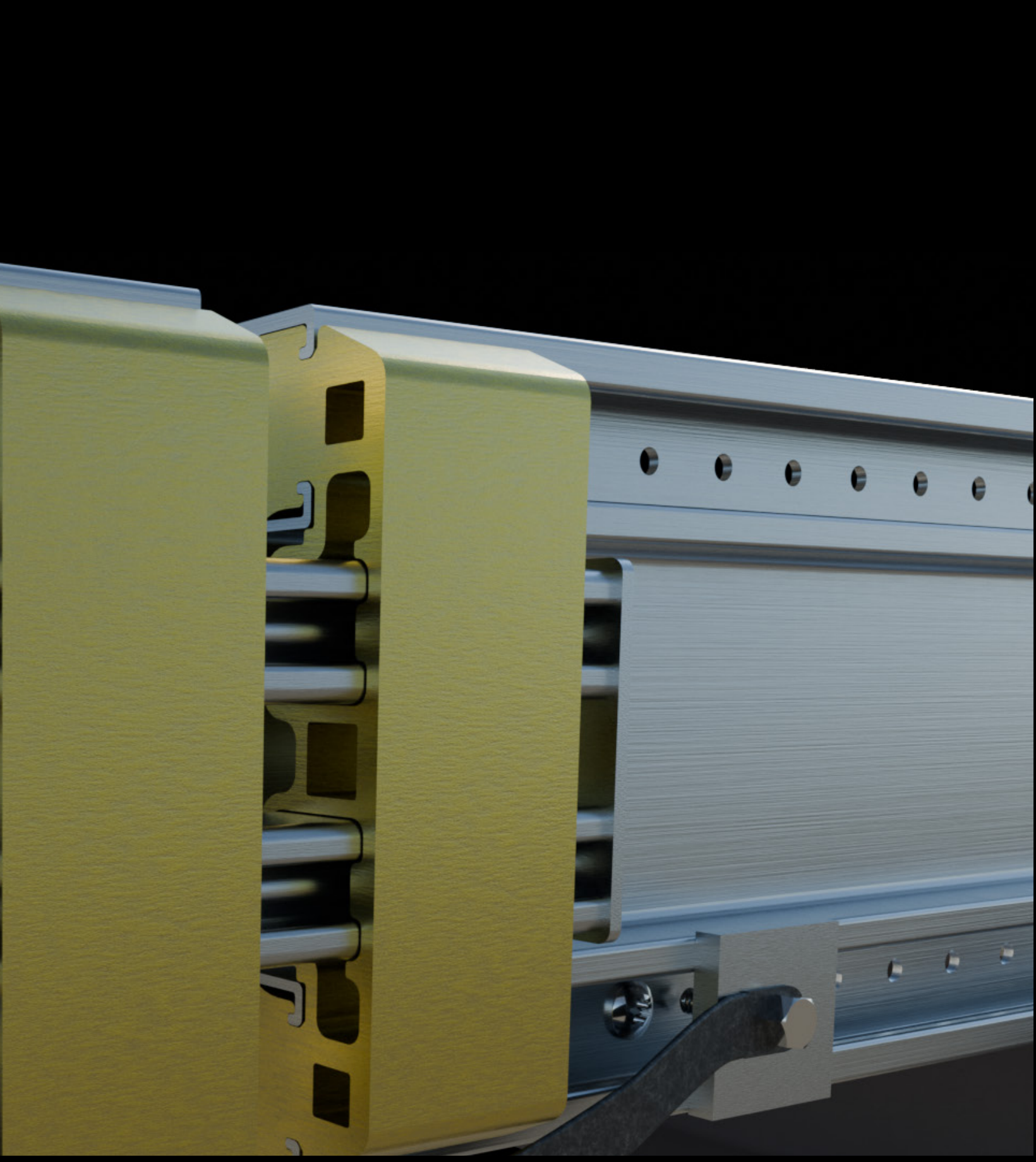
TOUGH SUPPORT SAVINGS

Manufacturer Recommendation:

- Support Within 2^{FT} of Vertical Drop
- Support Within Full Span of Fitting Union

Thermal Expansion:





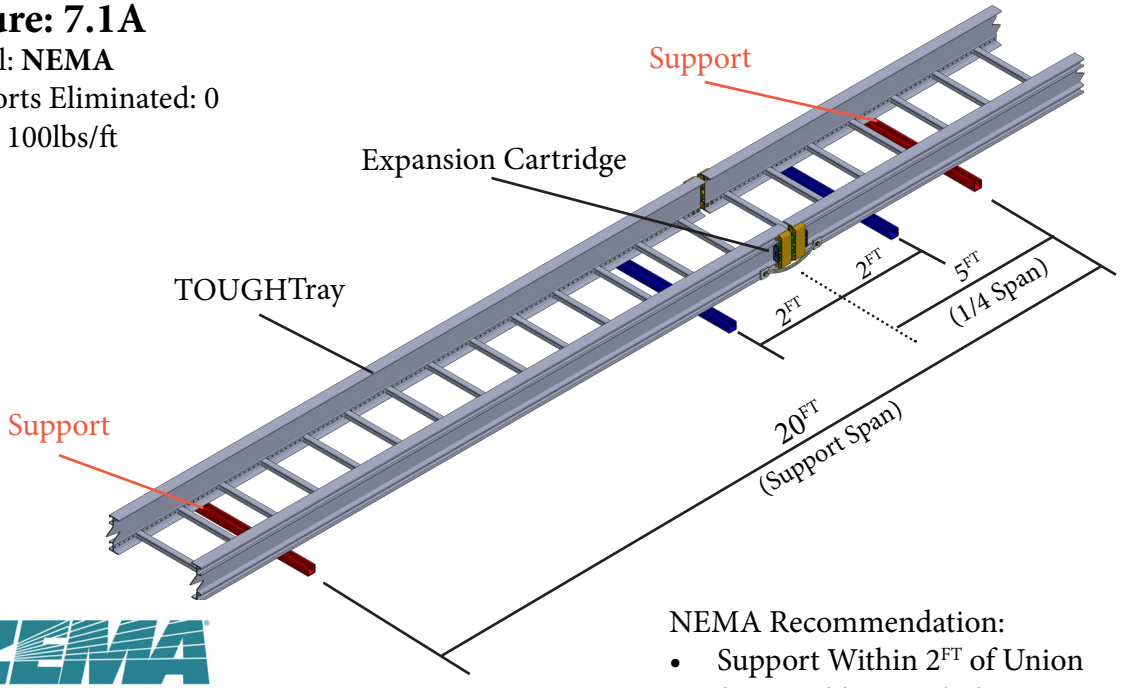
Support Location
Optimization

7.1 Horizontal Expansion Support Solutions:

Expansion joint design must provide maximum tray rigidity, minimum tray bending stress and deflection. Optimization is achieved by designing the expansion joint in the most efficient location to maximize tray rigidity, minimize tray bending stress and the quantity of expansion joint structural supports.

Figure: 7.1A

Install: **NEMA**
Supports Eliminated: 0
Load: 100lbs/ft

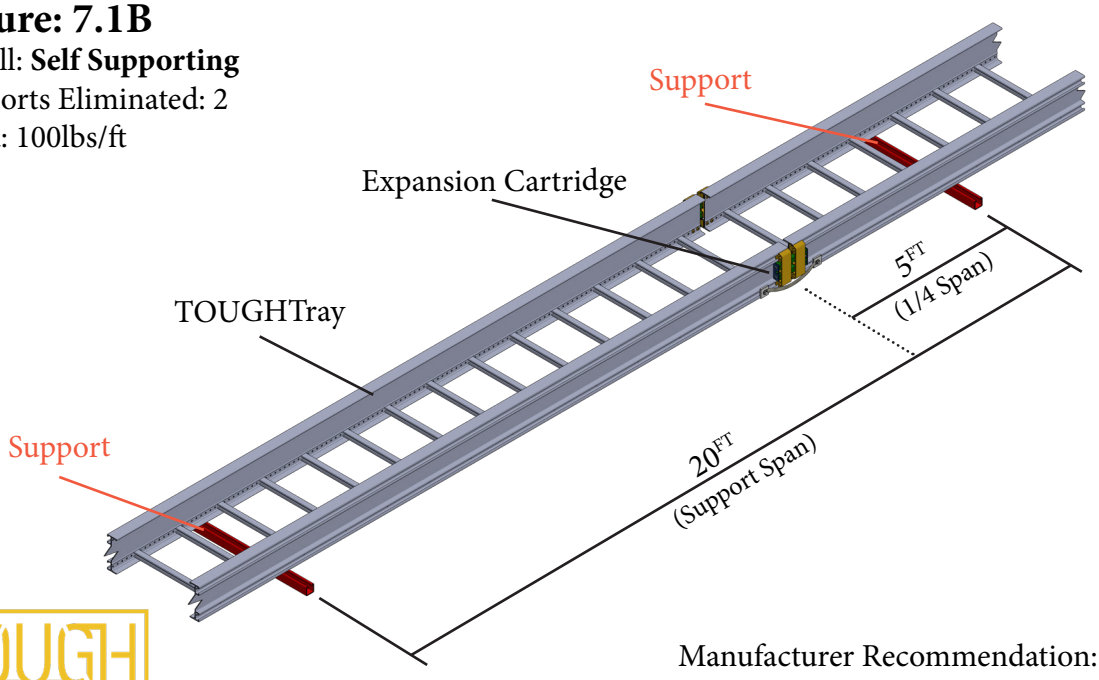


NEMA Recommendation:

- Support Within 2^{FT} of Union
- Support Tray at 1/4 Span

Figure: 7.1B

Install: **Self Supporting**
Supports Eliminated: 2
Load: 100lbs/ft



Manufacturer Recommendation:

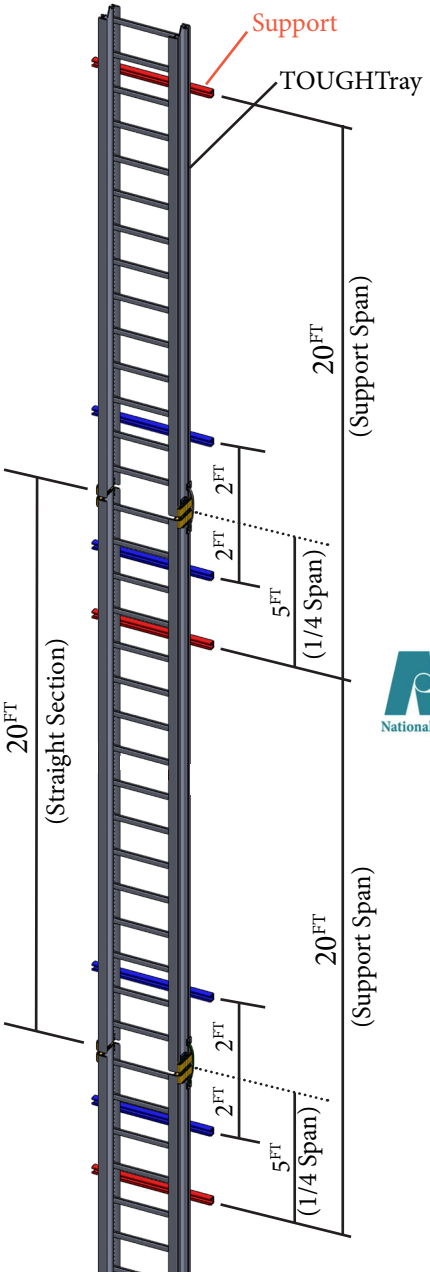
- Support Tray at 1/4 Span

7.2 Vertical Expansion Support Solutions:

Manufacturer Recommendations are provided for the efficient location and support of expansion joints within a continuous vertical tray run. Each straight section within a continuous vertical tray run must be anchored to the tray supports by HD Clamps and restrained to the expansion joint supports by HD Guides.

Figure: 5.2C (1/4 span)

Load: 100lbs/ft



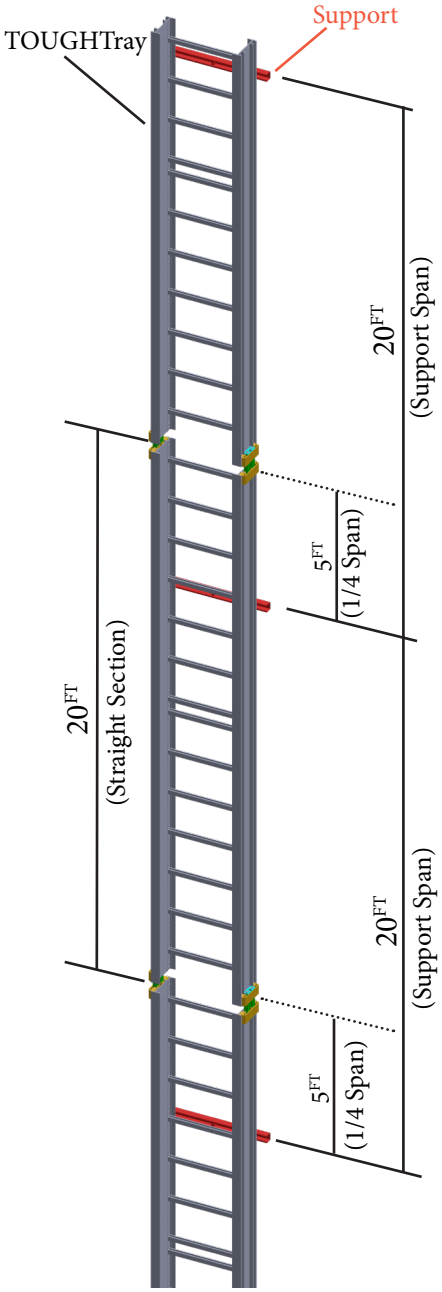
NEMA
National Electrical Manufacturers Association

NEMA Recommendation:

- Support Within 2FT of Union
- Support Tray at 1/4 Span

Figure: 5.2B (1/2 span)

Load: 100lbs/ft

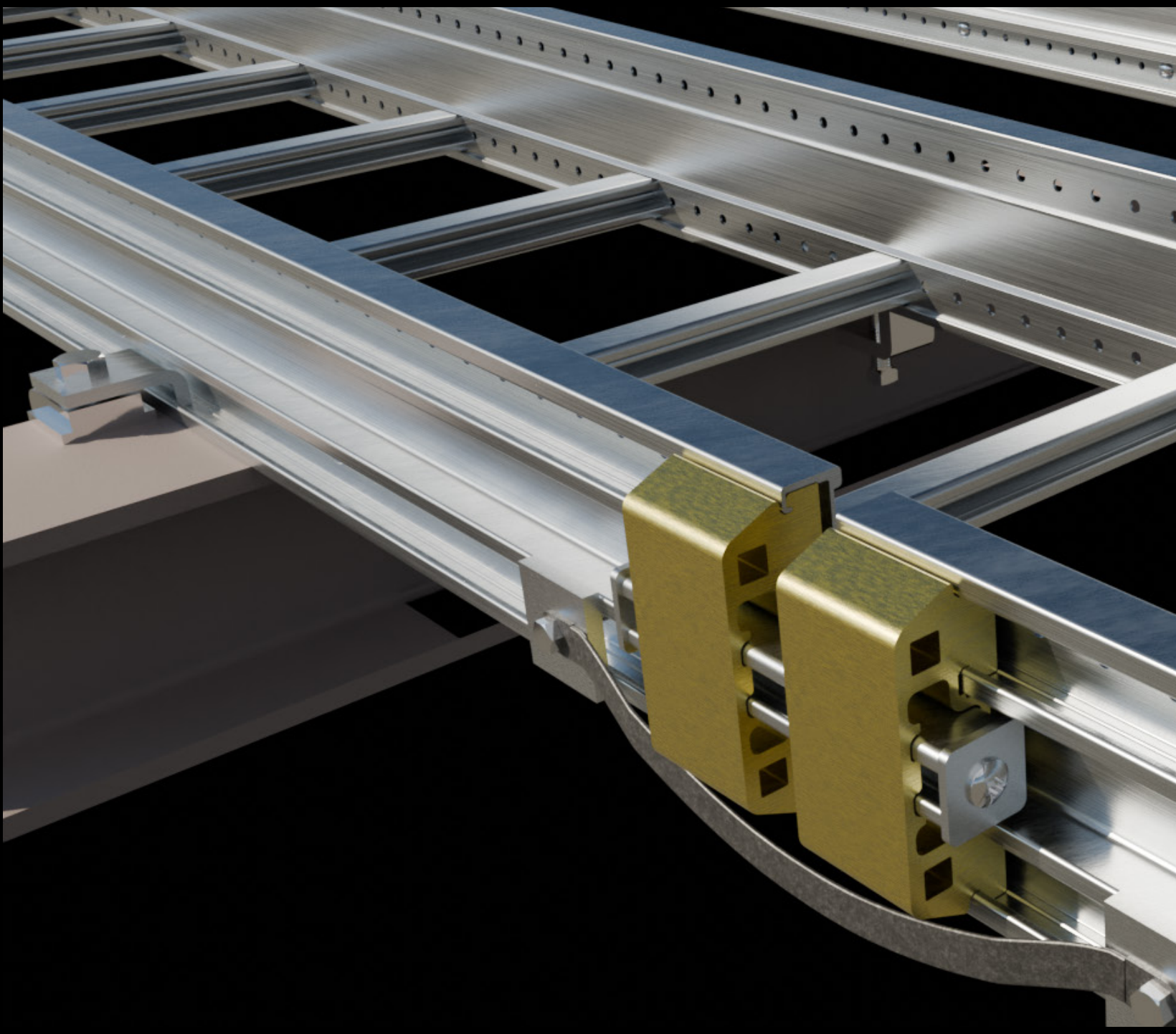


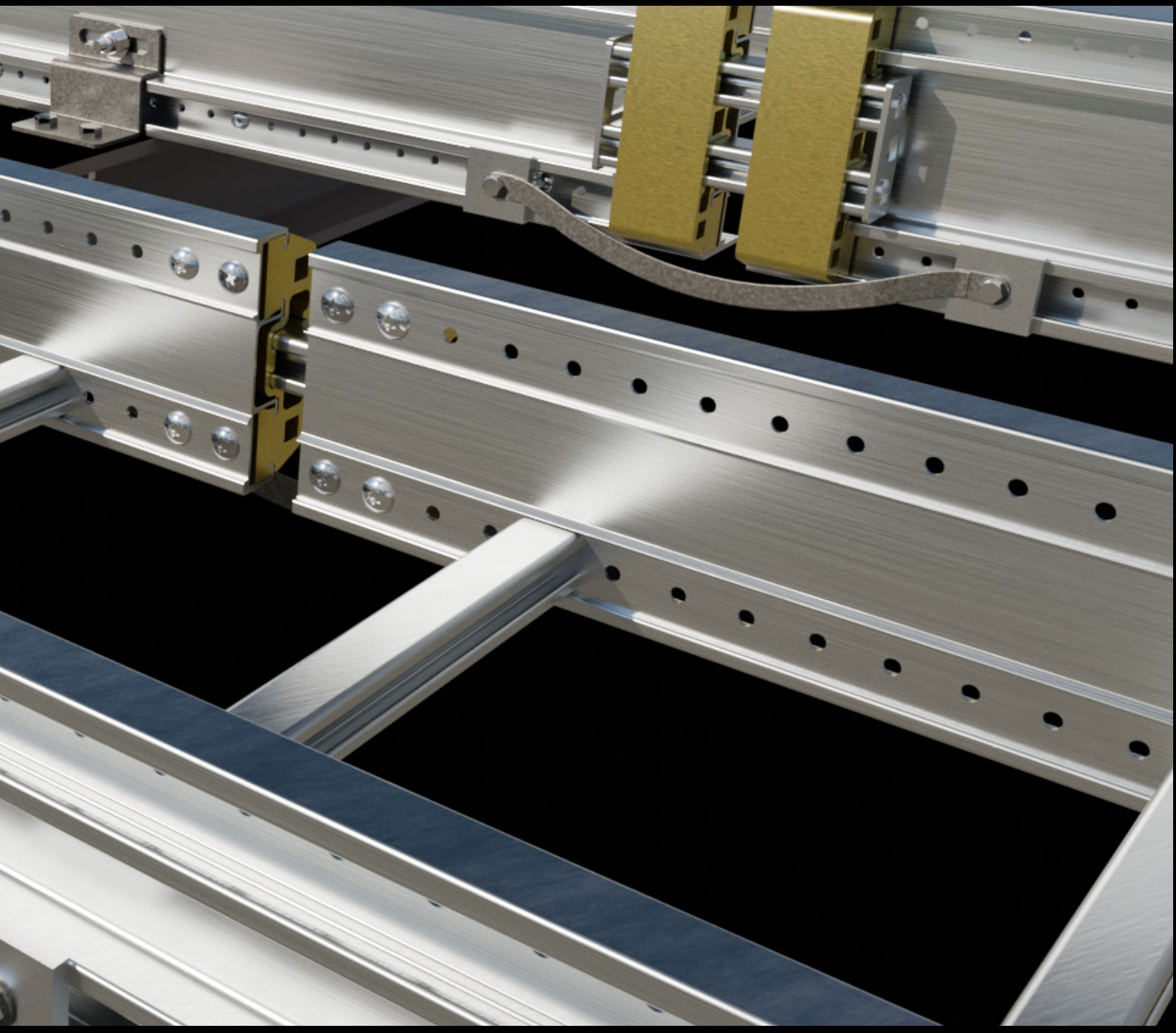
TOUGH SUPPORT SAVINGS

Manufacturer Recommendation:

- Support Tray at 1/4 Span

Technical Data





Calculations & Recommendations

8.1 Expansion Joint Calculations:

A cable ladder tray system will thermally expand and contract due to temperature changes. As the temperature reduces, the ladder tray will contract and will expand as the temperature increases. Cable ladder tray installations must incorporate features that provide adequate compensation for the thermal contraction and expansion.

Expansion joint spacing and quantity of expansion joints required within a continuous tray straight run is governed by the continuous straight run length, temperature differential, and the tray material.

The following step-by-step methods are provided:

Step-1: Determine the maximum spacing between expansion joints.
Step-2: Calculate the required quantity of expansion joints.

Step-1: Identify the maximum and minimum temperature at the project job site and calculate the (Δ) temperature differential. Once the temperature differential is calculated, determine the maximum spacing between expansion joints using Table 3-2 per NEMA VE-2 Section 3.4.2.

Example Calculation A:

Maximum Temperature: +38°C
Minimum Temperature: -32°C
Temperature Differential (Δ): +38 - (-32) = 70°C

Based on a 70°C (125°F) temperature differential, the maximum spacing between expansion joints when using Table 3-2 Aluminum is 52ft (16m).

Table 3-2: Maximum Spacing Between Expansion Joints That Provide for 1" (25mm) Move-

Temperature Differential*		Steel		Aluminum		Fiberglass	
°C	(°F)	m	(ft)	m	(ft)	m	(ft)
14	(25)	156	(512)	79	(260)	203	(667)
28	(50)	78	(256)	40	(130)	102	(333)
42	(75)	52	(171)	27	(87)	68	(222)
56	(100)	39	(128)	20	(65)	51	(167)
70	**(125)**	**31**	**(102)**	**16**	**(52)**	**41**	**(133)**
83	(150)	26	(85)	13	(43)	34	(111)
97	(175)	22	(73)	11	(37)	29	(95)

Step-2: Calculate the quantity of expansion joints by dividing the continuous ladder tray straight run by maximum spacing between expansion joints.

Example Calculation B:

Aluminum Continuous Cable Ladder Tray Straight Run: 2600ft
Aluminum Maximum Spacing Between Expansion Joints: 52ft
Quantity of Expansion Joints Expansion Cartridge Kits: 2600 ÷ 52 = 50

8.2 Expansion Support Calculations:

Expansion joints must be correctly spaced, located, anchored and restrained within continuous tray straight runs to maximize tray rigidity, to allow the expansion joint to freely expand and contract.

The following step-by-step design recommendations are provided:

Step-1: Support locations and savings value for expansion joint solutions.
Step-2: Calculate quantity of supports for expansion joint solutions.
Step-3: Design location of hold down clamps and expansion guides.
Step-4: Calculate quantity of hold down clamps and expansion guides.

Step-1: Support locations shall follow recommendations of Standard NEMA VE 2, Section 3.4.2 (see Figure- 7.1A Pg. 54) or Manufacturer Recommendations (see Figure-7.1B Pg. 54).

Step-2: To calculate the estimated quantity of supports for the selected expansion joint support recommendation [refer Step-1] the below Figure-A and Figure-B formulae can be used.

Figure-7.1A : 1/4 Span NEMA VE-2 Recommendation

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}}\right] \times 2 = \text{Support Quantity}$$

Figure-7.1B : 1/4 Span Manufacturer Recommendation

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}}\right] \times 0 = \text{Support Quantity}$$

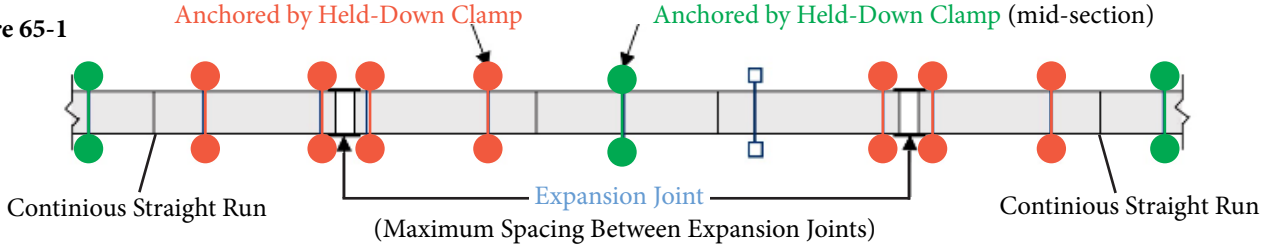
Note: Figure-B formulae will reduce expansion joint structural support quantities 100%

Step-3: Continuous horizontal ladder tray straight runs must be anchored and restrained to supports as shown in Figure 65-1 (below) and the manufacturers design recommendations.

Anchored by Hold-Down Clamp to the support nearest to mid-section between the expansion splice plates. Hold down clamp must prevent longitudinal movement of the cable ladder tray section that it anchors.

Restrained by Expansion Guide at all other support locations to allow the cable ladder tray to move longitudinally in both directions from the anchored mid-section. Expansion guide must allow longitudinal movement of the cable ladder tray section that it restrains.

Figure 65-1



8.2 Expansion Support Calculations:

Step-4: To calculate the quantity (per pair) of hold down clamps and expansion guides for the selected expansion joint recommendation (refer to Step-1) the below Figure-7.1A and Figure-7.1B formula can be used.

Figure-7.1A : 1/4 Span NEMA VE-2 Recommendation Expansion Guides

$$\left[\frac{\text{Continuous Straight Tray Run Support Span Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] + \left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 2\right] - \left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] = \text{Expansion Guide Qty}$$

Figure-7.1A : 1/4 Span NEMA VE-2 Recommendation Hold Down Clamps

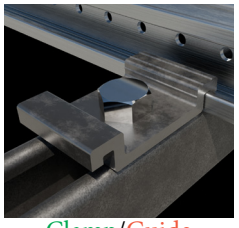
$$\left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] = \text{Hold Down Clamp Qty}$$

Figure-7.1B : 1/4 Span Manufacturer Recommendation Expansion Guides

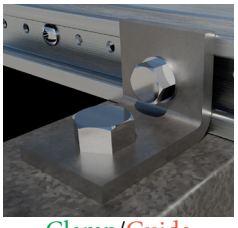
$$\left[\frac{\text{Continuous Straight Tray Run Support Span Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] + \left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 0\right] - \left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] = \text{Expansion Guide Qty}$$

Figure-7.1B : 1/4 Span Manufacturer Recommendation Hold Down Clamps

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints Ft}}{\text{Continuous Straight Tray Run Length Ft}} \times 1\right] = \text{Hold Down Clamp Qty}$$



Clamp/Guide



Clamp/Guide

HD Clamp

HD Guide

8.3 Expansion Joint Worked Calculations:

The following worked examples are given for each step detailed within Section 8.1 and Section 8.2 based on the following typical project design conditions:

- Ladder Tray Material: Aluminum
- Maximum Temperature: +38°C
- Minimum Temperature: -32°C
- Continuous Tray Straight Run Length: 52,000ft
- Continuous Tray Straight Run Support Span: 20ft

Section 8.1 Expansion Joint Spacing

Step-1: Determine the maximum spacing between expansion joints.

a. Calculate the Temperature Differential (Δ): +38 - (-32) = 70°C

b. Select max spacing between expansion joints (Table 3-2) for Aluminum 70°C = 52ft

Section 8.1 Expansion Joint Quantity

Step-2: Calculate the required quantity of expansion joints.

a. calculate quantity by:

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft.}}{\text{Continuous Straight Tray Run Length 52,000ft.}}\right] = \text{1000 Joints}$$

Section 8.2 Expansion Joint Support Recommendation

Step-1: select the preferred support recommendation Figure-7.1A or Figure 7.1B

a. Worked examples for recommendation Figure-7.1A and Figure 7.1B are given.

Section 8.2 Expansion Joint Support Quantity

Step-2: to calculate the required quantity of expansion joint supports.

a. Use the selected recommendations Figure-7.1A formula.

b. Calculate support quantity by:

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \text{ X } 2\right] = 2000$$

Section 8.2 Expansion Joint Support Quantity

Step-2: to calculate the required quantity of expansion joint supports.

c. Use the selected recommendations Figure-7.1B formula.

d. Calculate support quantity by:

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \text{ X } 0\right] = 0$$

8.3 Expansion Joint Worked Calculations:

Section 8.2 Expansion Guide and Hold-Down Clamp Location

Step-3: to design location of guides and clamps within a continuous straight tray run.

a. Locate the expansion guides and hold-down clamps as shown in Figure 65-1 on Pg. 59.

Section 8.2 Expansion Guide and Hold-Down Clamp Quantities

Step-4: to calculate the required quantity (per pair) of expansion guides and hold down clamps.

a. Use the selected recommendations Figure 7.1A formula.

b. Calculate expansion guide qty:

$$\left[\frac{\text{Continuous Straight Tray Run Support Span 20ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 2\right] + \left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 1\right] - \left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 1\right] = 3600$$

c. Calculate hold-down clamp qty:

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 1\right] = 1000$$

Section 8.2 Expansion Guide and Hold-Down Clamp Quantities

Step-4: to calculate the required quantity (per pair) of expansion guides and hold down clamps.

a. Use the selected recommendations Figure 7.1B formula.

b. Calculate expansion guide qty:

$$\left[\frac{\text{Continuous Straight Tray Run Support Span 20ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 2\right] + \left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 2\right] - \left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 2\right] = 1600$$

c. Calculate hold-down clamp qty:

$$\left[\frac{\text{Maximum Spacing Between Expansion Joints 52ft}}{\text{Continuous Straight Tray Run Length 52,000ft}} \times 1\right] = 1000$$

8.4 Expansion Joint Gap Calculations:

The expansion joint gap must be correctly calculated and properly set during its time of installation to allow the tray to thermally expand and contract freely within the gap.

There are two (2) recommendations available to the designer and installer; these are:

A. to follow Manufacturer Recommendations
B. to follow Industry Standard Practice

Instructions are given below to calculate the expansion gap setting for recommendation A and B.

A. Manufactuer Recommendations

1. Expansion Catridge Kit must be installed at every expansion joint.
2. Instal a cartridge within the pre-installed TOUGHLink cartridge keyhole.
3. Set the expansion joint gap to the recommended 1-inch (25mm).

Design Notes:

1. 1-inch (25mm) expansion gap is recommended for all design temperature differentials.
2. Gap recommendation applies to all ambient site temperatures at the time of installation.

B. Industry Standard Practice: NEMA VE 2

Industry Standard Practice follows NEMA VE 2 recommendations and based on the use of expansion splice plates. Accurate gap setting at the time of tray installation is necessary for the proper operation of the expansion joint splice plate.

The following NEMA VE-2 Section 3.4.2 industry standard practice should be followed to calculate the expansion gap setting at the time of installation. Temperature is tray surface temp.

1. Plot the highest expected temperature on the maximum temperature line (Example: +100°F)
2. Plot the lowest expected temperature on the minimum temperature line (Example: -30°F)
3. Draw a line connecting the maximum and minimum points identified in Step 1 & 2.
4. To determine the gap setting, plot the tray temperature at time of installation (Example: 50°F) and draw a horizontal line. Where the horizontal line intersects the diagonal line between maximum and minimum temperature points, draw a vertical line projected downward to determine the gap setting. This example determines required expansion gap setting between cable tray ends is 3/8" (9.5mm).

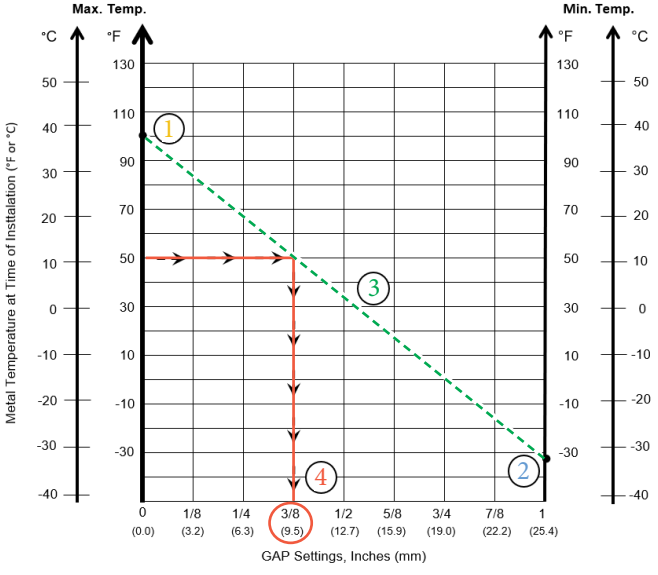


FIGURE 65-3: Gap Setting of Expansion Splice Plate, 1in (25.4mm) Gap Maximum

Rev: A

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