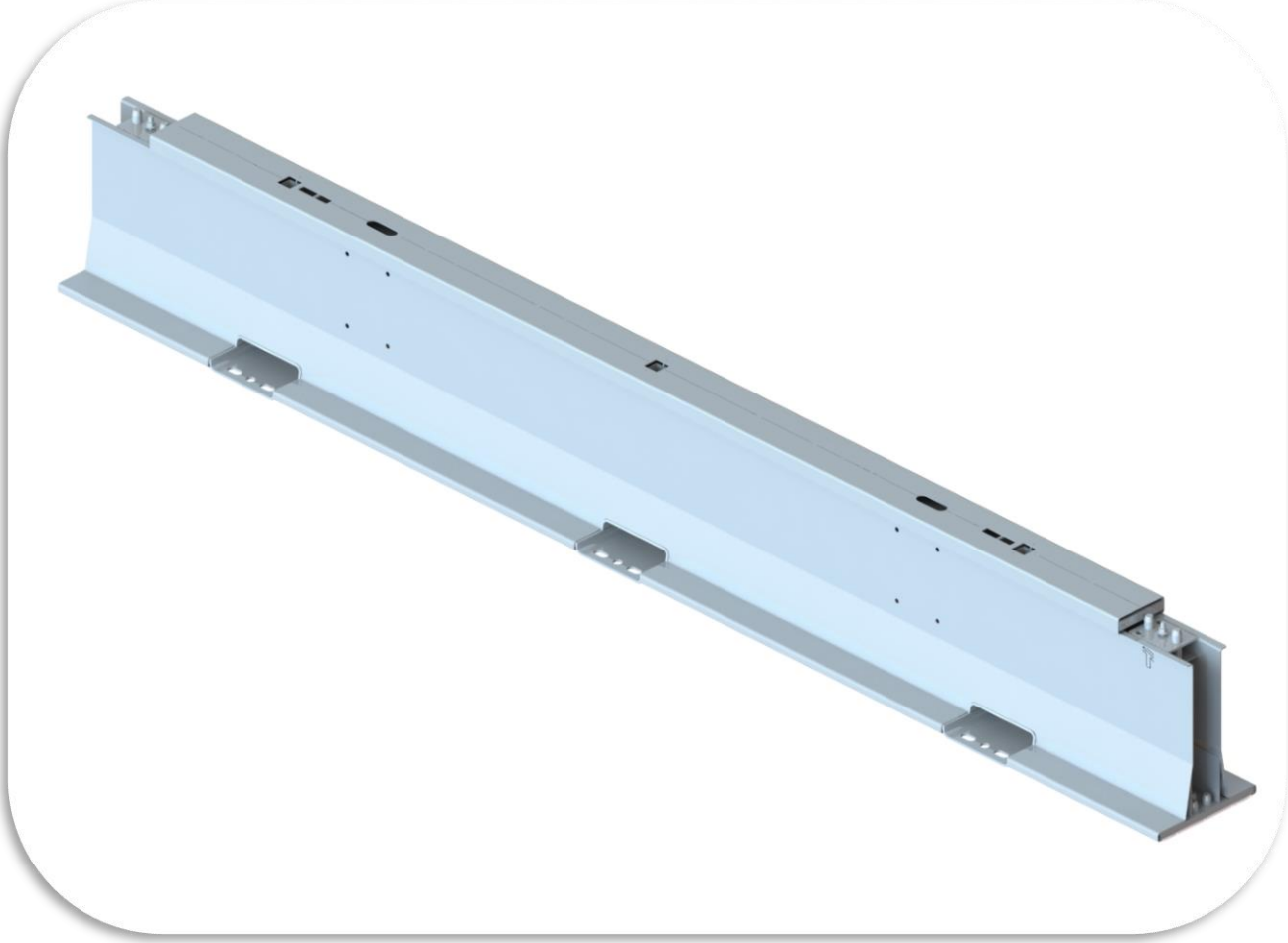
HighwayGuard™

Australia & New Zealand

Standard System Product Manual



Revision History

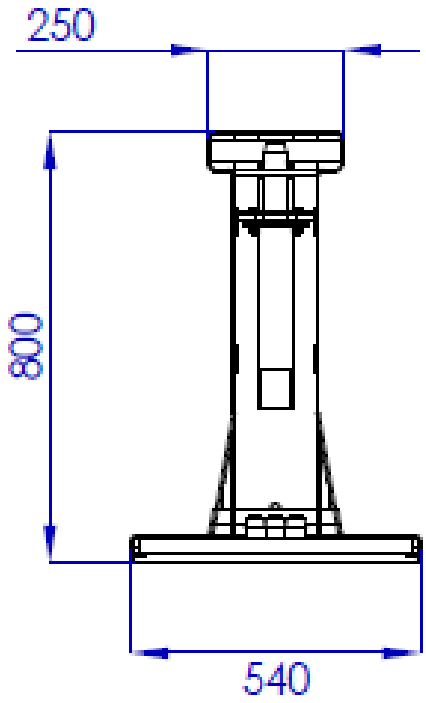
Revision	Date	Prepared by	Approved by	Reason for change
1.0	December 2019	O. Pulling	L. Hotchkiss	First issue.
1.1	May 2020	A. Marsh	O. Pulling	Anchor section update.
1.2	September 2020	A. Marsh	O. Pulling	Anchor section update for NCHRP 350 crash cushions.
1.3	November 2020	O. Pulling	A. Marsh	Absorb M & barrier removal section added.
1.4	March 2021	O. Pulling	A. Marsh	QuadGuard M10 added.
1.5	May 2021	A. Marsh	O. Pulling	12m section and TAU M added.
1.6	February 2022	A. Marsh	O. Pulling	Pavement and anchor update.
1.7	May 2022	A. Marsh	O. Pulling	Permanent installation added.
1.8	November 2022	A. Marsh	O. Pulling	ArmorBuffa added.

Contents

Introduction

HighwayGuard™ is a MASH 16 TL-3 & TL-4 compliant steel safety barrier. The 6m single barrier section, with the unique T-Connector provides quicker installation, removal, and separation of barrier sections. It also offers the ability to remove sections within a run to create access gaps, replace damaged sections or alter barrier runs.

HighwayGuard™ is an anchored steel safety barrier that can be used in temporary and permanent applications.

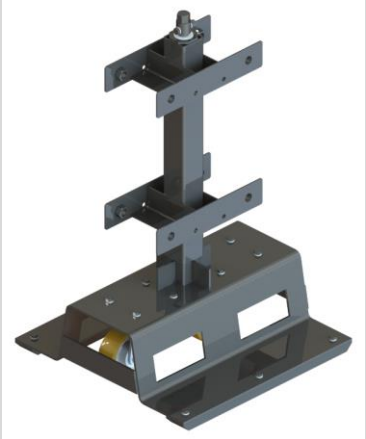
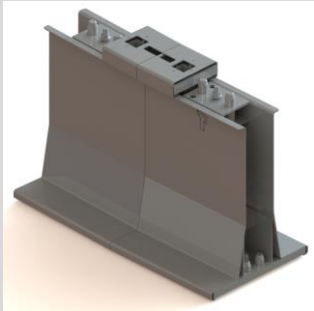
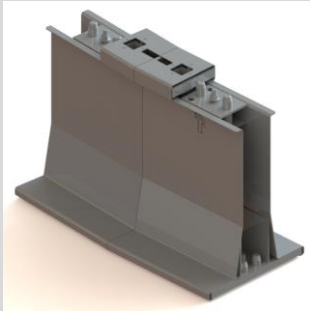
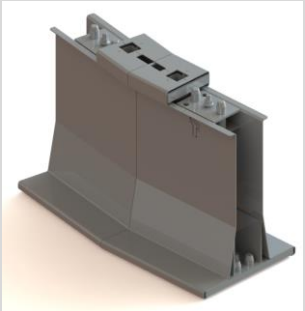


Containment Level	Weight	Standard Barrier Length
MASH TL-3 & TL-4	99Kg per Metre	6m

System Components

6m Barrier	12m Barrier	End Cap
 552kg	 1034kg	 27kg

Standard T-Connector	2.5 Degrees T-Connector	5 Degrees T-Connector	10 Degrees T-Connector
 43kg	 60kg	 60kg	 60kg

Wheelsets	2.5 Degrees Barrier	5 Degrees Barrier	10 Degrees Barrier
 27kg	 133kg	 134kg	 136kg

Note: Weights are approximate only.

Design Considerations

It is important that HighwayGuard™ is planned/designed and installed in accordance with this manual and any approval/regulatory conditions placed upon its acceptance use in that territory.

Delineation

Reflective delineators may be required for both permanent and temporary applications. The specification (size, shape, colour, position) can vary in accordance to meet local regulations/requirements.

Drainage

HighwayGuard™ has a 10mm drainage gap underneath the barrier. Additional drainage provision is provided at anchor points. The water drainage per 12m section is approximately 1.15sqm.

Pavement Types

HighwayGuard™ has been tested installed on asphalt pavement that is 150mm asphalt concrete over a granular subbase.

In addition, HighwayGuard has also been tested in compacted AASHTO Grade B Soil-Aggregate 400mm deep, tamped with a hydraulic compactor.

Alternative ground conditions may be acceptable but could require different anchor solutions.

Install Lengths

The permissible length of the system is unlimited, but the barrier must be anchored at the end of each run and intermediately as required by the system type.

The recommended minimum length of barrier when installing in asphalt is 72m (12 sections). This allows 58m anchor spacing to replicate tested intermediate anchor spacing.

The recommended minimum length of barrier when installing in AASHTO soil or equivalent is 108m (18 sections) as tested.

For additional installation length guidance, please contact Highway Care for advice.

Curves

The T-Connector can allow an approximate angle of up to 0.23° for vertical connections and 0.77° between barrier sections for horizontal connections. Example horizontal curves;

Method	Description	Approximate Radius (m)
1	6m Barrier Section with Standard T-Connections at maximum angle	177
2	6m Barrier Section with 2.5° T-Connection	140
3	6m Barrier Section with 5° T-Connection	70
4	6m Barrier Section with 10° T-Connection	35
5	6m Barrier Section with 10° Barrier Section and Standard T-Connection	41
6	12m Barrier Section with Standard T-Connections at maximum angle	354
7	12m Barrier Section with 2.5° T-Connection	280
8	12m Barrier Section with 5° T-Connection	140
9	12m Barrier Section with 10° T-Connection	70
10	12m Barrier Section with 10° Barrier Section and Standard T-Connection	82
11	10° Barrier Section with Standard T-Connection	6.6
12	10° Barrier Section with 10° T-Connection	3.6

Deflection/Clear Zone

HighwayGuard™ is designed to absorb energy when impacted. When impacted between anchors deflection occurs. No hazards or obstacles should be in the deflection area such as kerbs, work materials/equipment.

Vehicle roll should be considered with taller vehicles as these may protrude beyond the barrier deflection during impact.

Crash Cushions/Other Connections

Crash cushions should be used when impact to either the approach or departure end of a run of HighwayGuard™ may occur.

Current Crash cushions/ Connections available;

<u>Permanent & Temporary use</u>

- QuadGuard M10 (MASH Compliant)
- TAU M (MASH Compliant)
    - Only accepted for use in uni-direction applications

<u>Temporary use only</u>

- Absorb M (MASH Compliant)
- ArmorBuffa (MASH compliant)
- QuadGuard CZ Crash Cushion (NCHRP 350 Engineered)
- Tau II Crash Cushion (NCHRP 350 Engineered)

An engineered connection is one that has been designed and jointly agreed by Highway Care and the crash cushion developer as acceptable for use. These may also require approval from relevant road authorities – check road authority approval for guidance on acceptable options available in your market.

Modifications

No modifications are allowed to HighwayGuard™ components without prior approval from Highway Care.

Crash Testing & Performance Levels

HighwayGuard™ has been tested to the MASH (2016), a brief guide showing performance levels and individual tests required is shown below for reference.

Test Standard	Performance Level	Test Reference	Vehicle Type	Impact Speed (km/h)	Impact Angle (˚)	Vehicle Mass (kg)
MASH	TL-3	3-10	Light Car	100	25	1100
		3-11	Pickup	100	25	2270
		3-21	Pickup	100	25	2270
	TL-4	4-10	Light Car	100	25	1100
		4-11	Pickup	100	25	2270
		4-12	Truck	90	15	10000

System Type	Anchor Interval (m)	Test Standard	Performance Level	Dynamic Deflection (m)	Working Width (m)
HighwayGuard™ Standard	58[1]	MASH 16	TL-3	1.93	2.47
			TL-4	2.16	3.51
	42[2]		TL-3	1.85	2.10

[1] Standard System anchor arrangement – refer to installation section or drawing HG-70-01 for further detail.

[2] 42m reduced anchor spacing using driven pins for use when installing in AASHTO soil or equivalent pavement types

Installation

HighwayGuard™ must be installed in accordance with this manual and with the latest state road authority conditions. Where conflict arises road authority conditions take priority over this manual.

Planning

Prior to starting an installation, it is recommended that the customer informs the installer of;

- Start/end positions and alignment requirements of each barrier run (including crash cushions)
- Curvature (horizontal and vertical) required to ensure appropriate components available
- Installation site risks identified (e.g. overhead cables, bridges, tunnels, drilling limitations)
- Traffic management measures in place to ensure appropriate and safe working space

Tools List

(T)ool / (C)onsumable	Information
(T) Magnetic T-Bar Socket	For inserting and removing the T-Connector security nut.
(T) Drilling Equipment	Electric or air driven rock drill. Suggested drill bits 32mm (M30 drop in pins) 400mm long.
(T) Measuring Wheel & (C) Road Marking Paint	To mark barrier position where required.
(T) 2 off 2m crow bar/wrecking bar	To assist with minor barrier re-alignment.
(T) Timber Blocks	To aid installation/removal on uneven ground.
(T) Sledgehammer	For driving anchor pins into AASHTO or equivalent pavement types.
(T) Wrench	With 36mm socket.

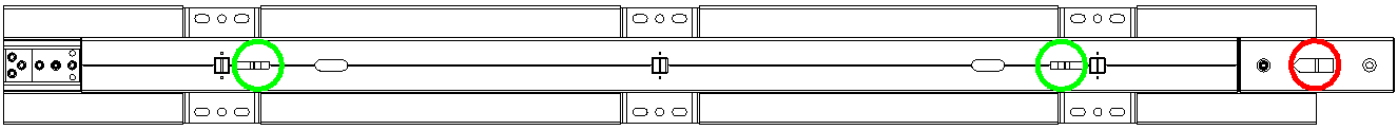
Lifting points

Caution

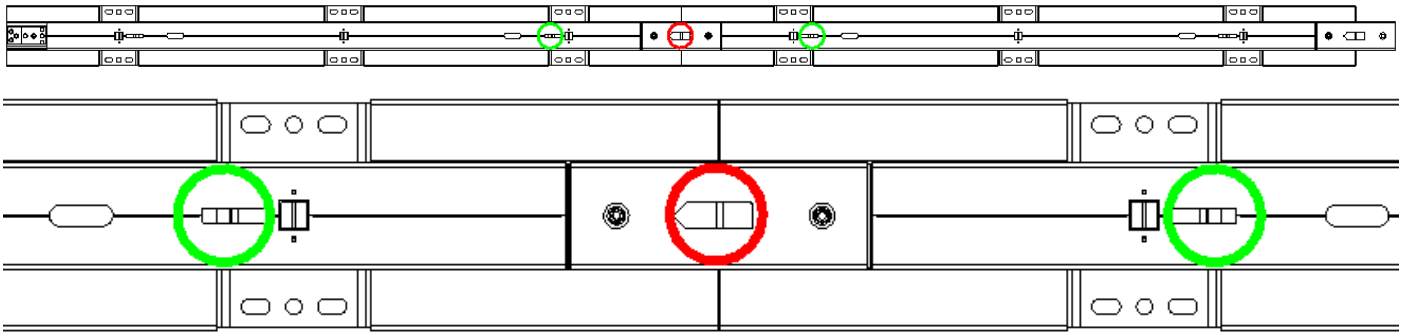
Do not use the T-Connection lifting points to lift barrier sections (highlighted by red circles). These are for lifting the T-Connection only.

Ensure lifting equipment is certified and in a safe/useable condition.

Each 6m barrier section has two designated lifting points allowing hooks to attach marked in green below.



When two 6m sections are bolted together they can be lifted as a single 12m piece using the lifting points either side of the central T-Connection.



Note: There are also lifting points on the underside of the HighwayGuard at the feet locations.

Lifting Equipment	Information
Mechanical/Pneumatic Lifting Device	Such as a lorry mounted crane or wheeled excavator. It must have suitable lifting capacity and reach to install HighwayGuard™.
Lifting Chains	Two leg assembly with a 2500kg lifting capacity, each chain is 2m long c/w hook, locking clasp and shortening clutch.
Tag Rope	Suggested 1.5 times the lifting height of the barrier.

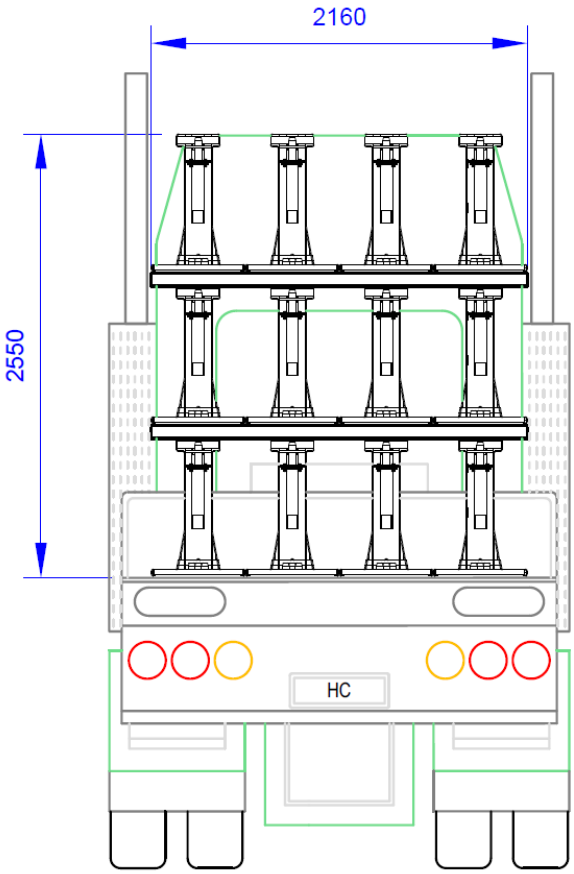
Loading/Unloading

Caution

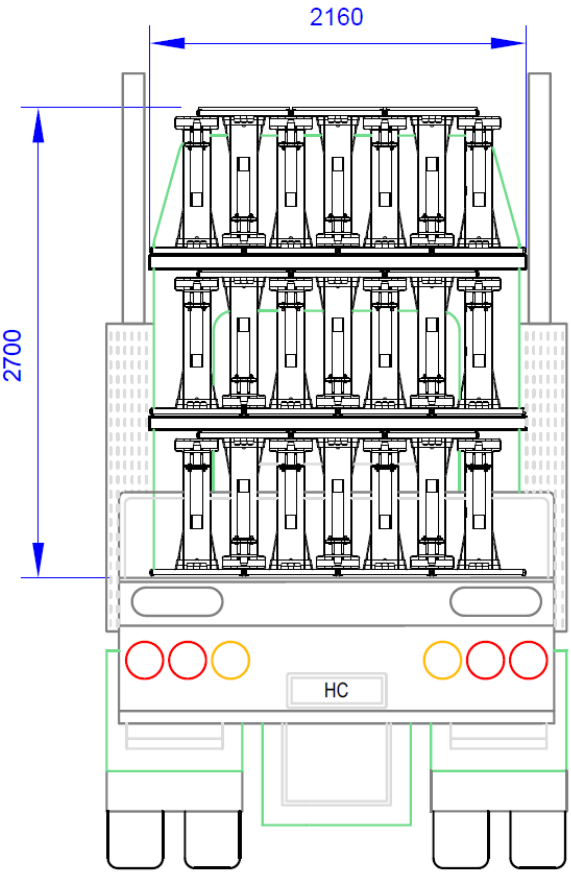
Ensure all barrier sections are secured to the truck bed with adequate ratchet straps prior to transport movements.

HighwayGuard™ can be inverted to maximise the length of barrier per load.

Check local regulations for potential weight/transport restrictions.



144m Upright

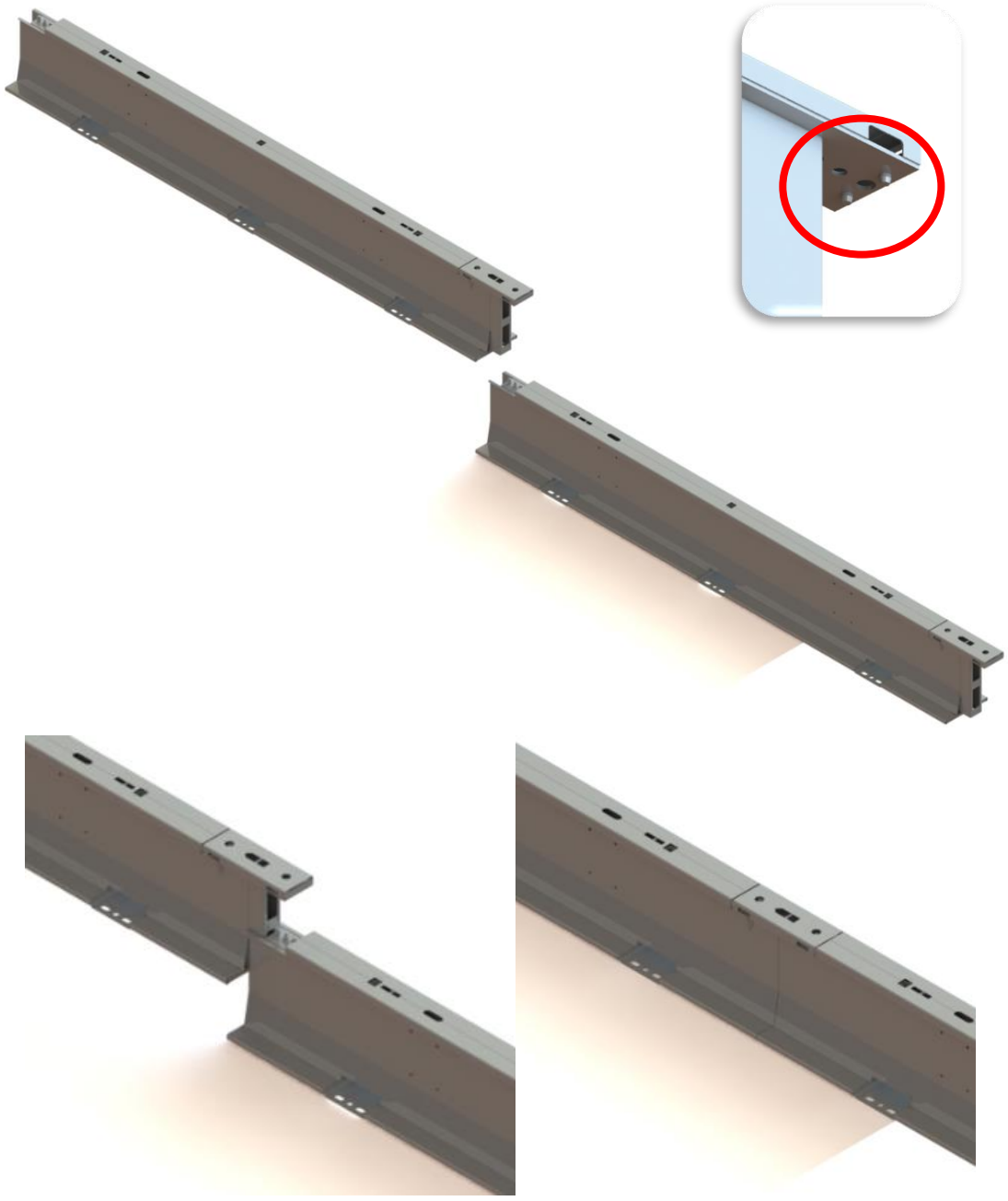


252m Inverted

When loading with the T-Connection attached to barrier sections; position these so that they will match the orientation of the install to avoid turning barrier round on site. Typically they will be at the rear of the trailer.

Connection

Barrier sections are lowered into position with the T-Connection already attached to the end of the barrier that is being joined to the run of barrier. Ensure orientation of T-Connector allows alignment pins to be lowered onto next section.



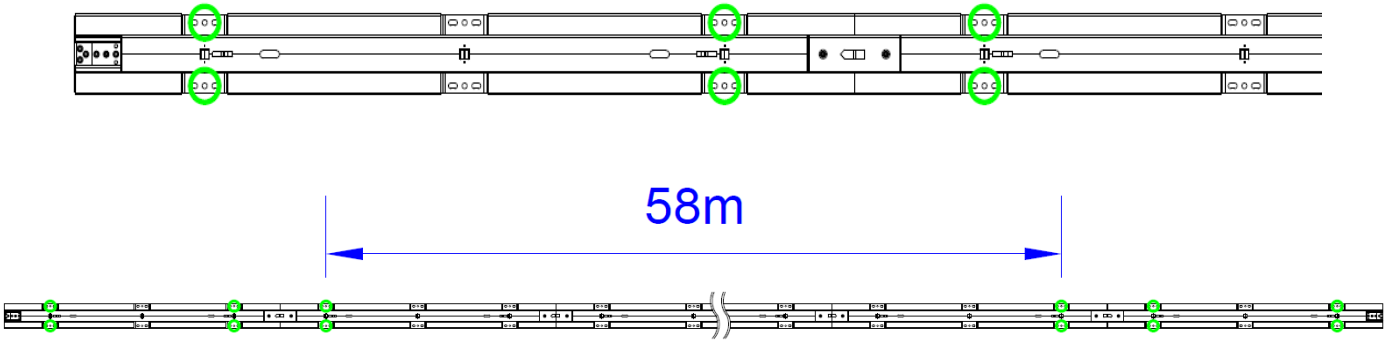
Caution

Ensure all barrier sections being lifted have a tag line attached. Joining barrier sections presents a crush risk, ensure operator has clear view and communication ability when barriers are being aligned and connected.

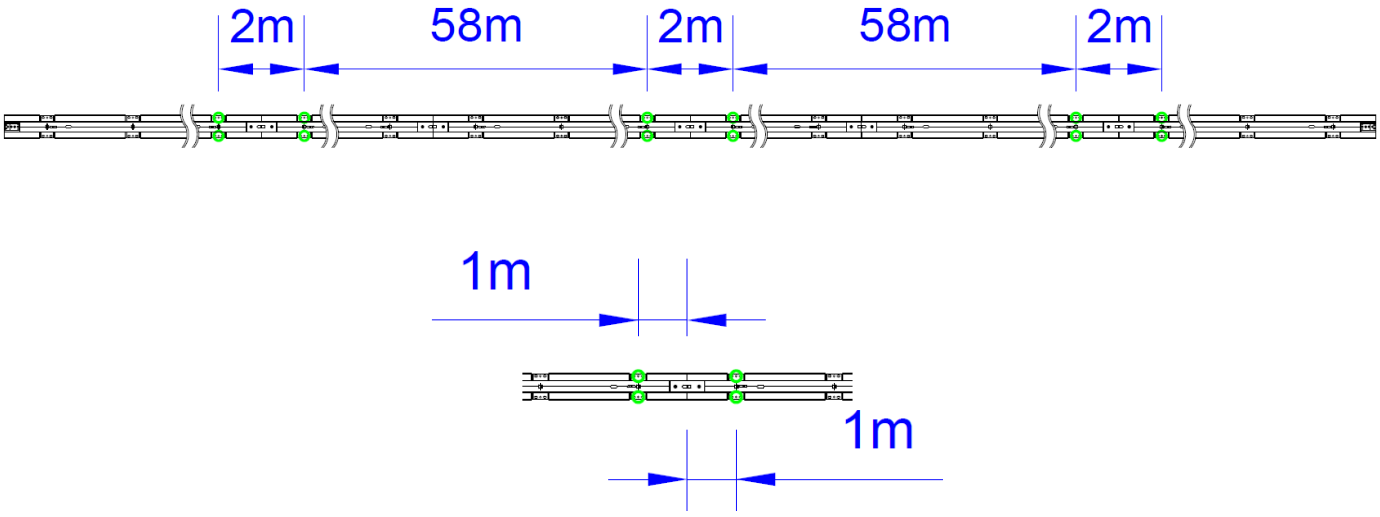
Anchoring

Standard

HighwayGuard™ requires a minimum of 6 anchors in the first two 6m barrier sections and the last two 6m sections. If no crash cushion is connected, then these can be drop in pins for the standard system. The standard system was tested with M30 drop in pins (32mm drill bit) with 350mm embedment.

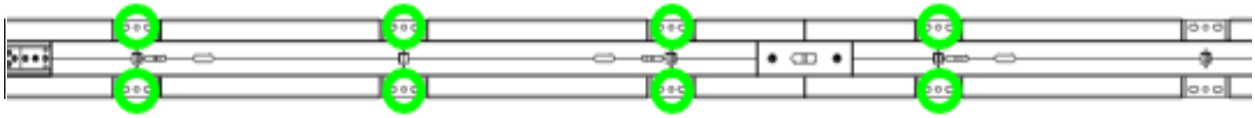


For Standard System installation where longer runs are required, 4 anchors are then added every 58m as shown below;

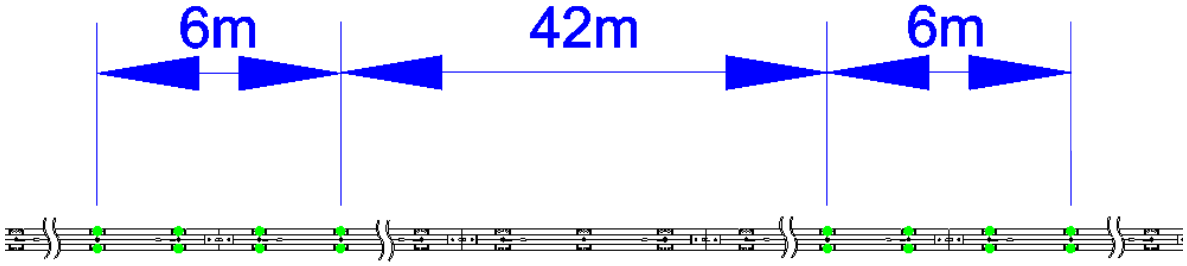


Standard AASHTO

For installation in AASHTO or flush seal pavement types using driven pins a minimum of 8 anchor points are required at the first and last sections in a run of barrier.



When installing into AASHTO soil or flush seal pavement types the anchor interval must be reduced to 42m intervals and anchored as shown below using driven pins.



The AASHTO system was tested with M30 driven pins with 500mm embedment.

For additional anchor details and information, please refer to drawing: HG-60-12 – HighwayGuard Foundation Details (extract Shown in manual appendix).

Crash Cushions

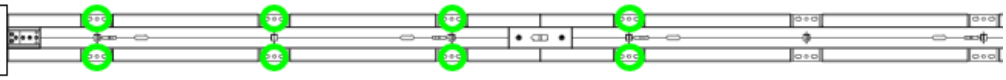
Crash cushions or connections/transitions should be used when impact to either the approach or departure end of a run of HighwayGuard™ may occur.

Currently accepted are;

- QuadGuard M10 (MASH Compliant)
- TAU M (MASH Compliant)
- Absorb M (MASH Compliant)
- ArmorBuffa (MASH compliant)
- QuadGuard CZ Crash Cushion (NCHRP 350 Engineered).
- Tau II Crash Cushion (NCHRP 350 Engineered).

When using crash cushions (both NCHRP 350 or MASH) HighwayGuard™ must be anchored at the start and end of runs at the below anchoring locations with M24 grade 8.8 resin threaded bar (28mm drill bit) with 400mm embedment.

CRASH CUSHION



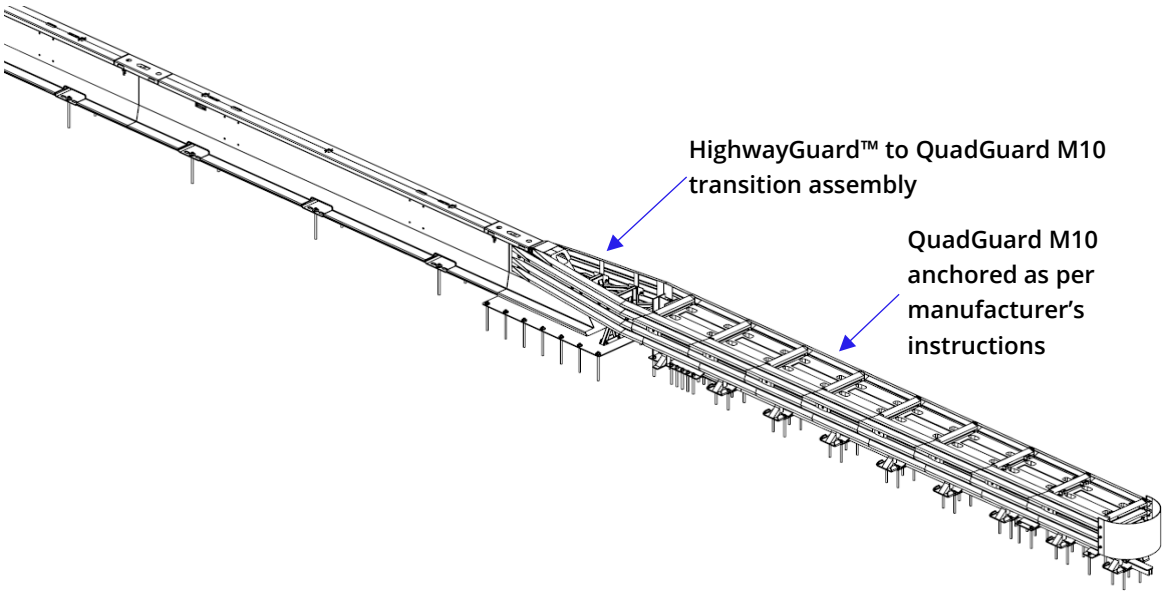
Check the latest state approvals for crash cushion compatible pavement types and additional requirements.

It may be necessary to install the first/last HighwayGuard sections onto an adjoining concrete pad when connected to a redirective crash cushion.

QuadGuard M10

In addition to HighwayGuard™, when using the QuadGuard M10 the transition assembly must also be anchored with 14 off M20 grade 8.8 resin threaded bar (24mm drill bit) with 400mm embedment as shown below (7 anchors either side of the transition assembly).

When installing into AASHTO soil or flush seal pavement types the QuadGuard M10 transition assembly must be installed on a concrete pad, see drawing HG-60-22.



Barrier Removal

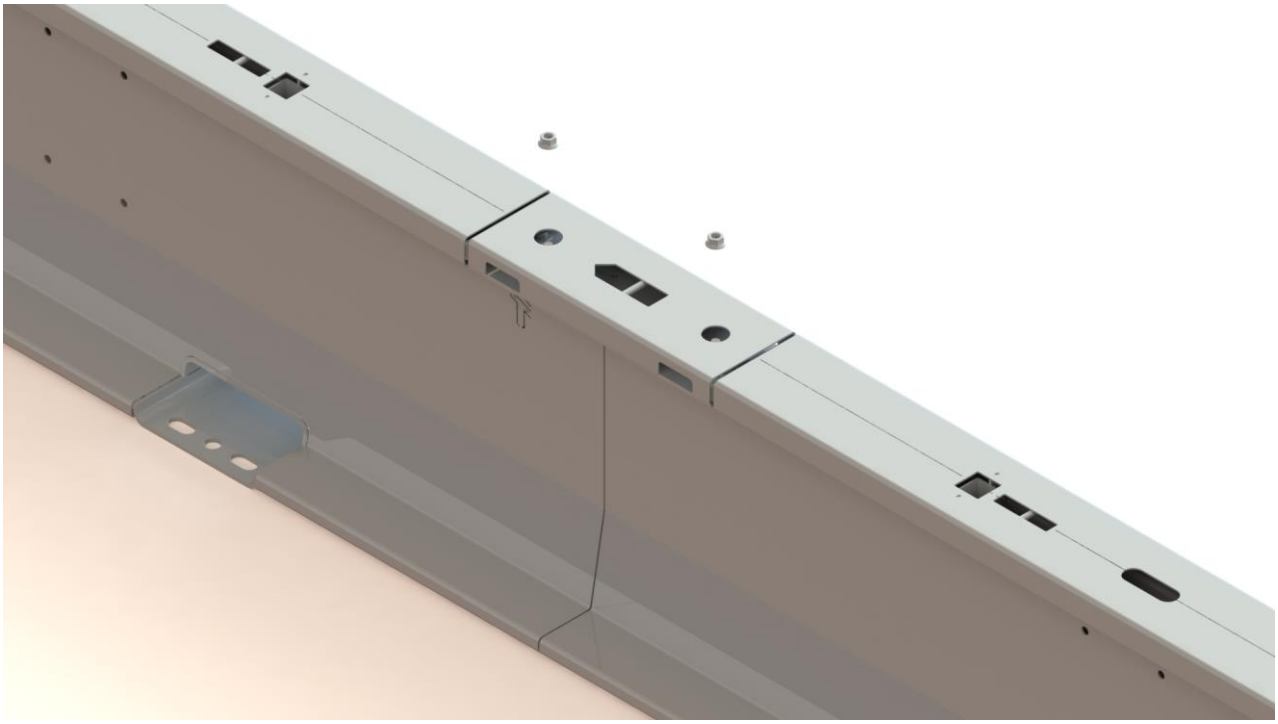
To remove the barrier sections it is the reverse of the installation process. Namely;

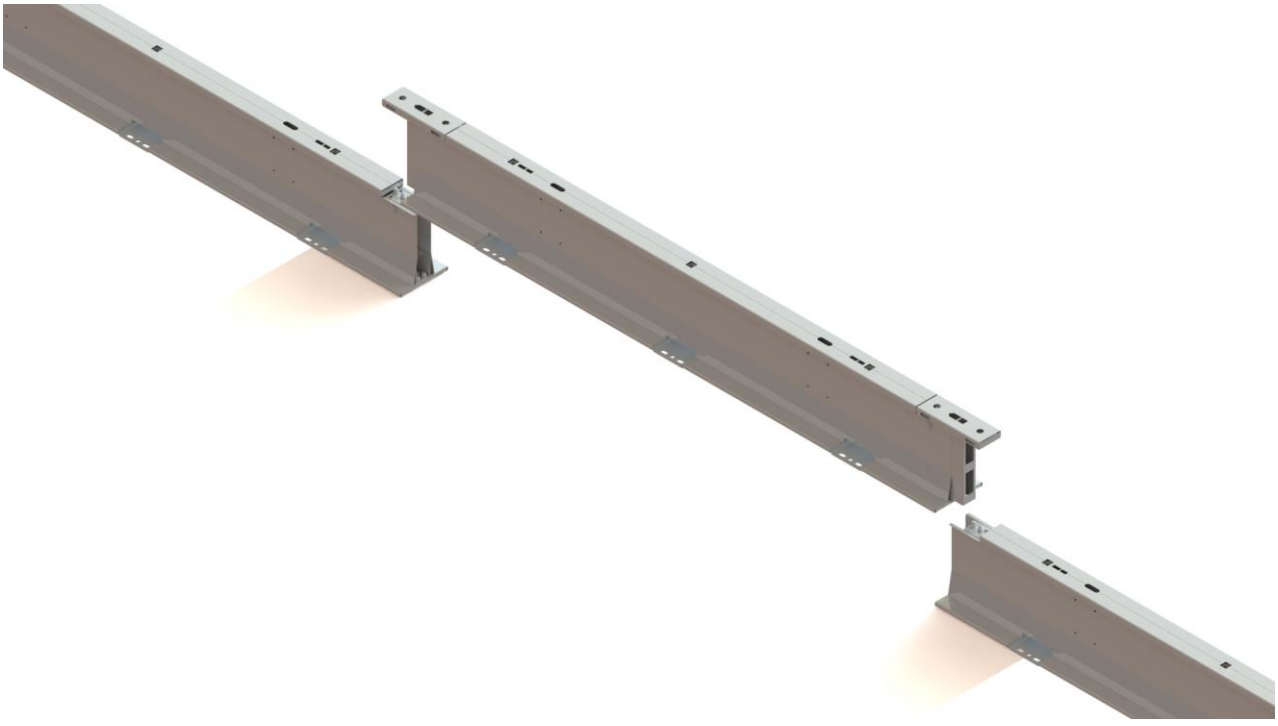
- Unbolt from the ground
- Remove security nut from the side of the T connector you wish to sperate
- Lift barrier section and T connector from adjoining
- If the section of barrier being removed lifts the next section, place a 50mm high block under the foot of the section being removed next to the joint to be separated and lower the barrier. It will then separate.

Special Operations

Creating Access Gap

Lift out individual sections by disconnecting the T-Connection and removing the security nut. The section can now be lifted out.





Bridges

Where possible anchoring should take place off bridge decks. Any anchoring on bridge decks needs to be agreed in advance with the technical expert responsible for the bridge to ensure it is not damaged. If anchoring either side of a bridge deck expansion joint then this movement must be mirrored in the barrier by utilising a variable length barrier section.

Wheelsets

These allow barrier sections to be manoeuvred without lifting machinery/equipment such as installing in tunnels or areas with overhead restrictions.

The wheelsets can be raised and lowered from the top of the barrier using a manual wrench and 24mm socket.

Caution

Impact guns should not be used to operate the wheels.

Pavement

HighwayGuard™ has been tested on asphalt pavement that is 150mm asphalt concrete over a granular subbase. The standard system was tested with M30 drop in pins (32mm drill bit) with 350mm embedment.

The AASHTO soil test was installed with M30 driven pins with 500mm embedment. *Note, for installation AASHTO soil or equivalent pre-drilling is not permitted, the pins must be driven.*

Check that the flat top/driven pins are fully embedded and sit flat on the feet of HighwayGuard.

Alternative ground conditions may be acceptable but might require different anchor solutions.

For additional pavement details and information, please refer to drawing: HG-60-12 – HighwayGuard Foundation Details (extract Shown in manual appendix).

When using grade 8.8 M24 threaded bar set with resin based on trials conducted at the test facility it is recommended that the resin anchor is able to withstand a pull out force of 95kN (28mm hole with 400mm embedment).

RoadLoc® M24 x 330mm removable anchors can be installed in the appropriate pavement type.

Maintenance and Repair

HighwayGuard™ is generally a maintenance free barrier. It is recommended that some basic maintenance is carried out on the system every 10 years, this involves a visual check for signs of corrosion/damage both outside and inside the barrier.

For wheeled sections ensure that they are raised/lowered and maneuvered around, greasing the jacking mechanism if required on an annual basis.

Any damage to the galvanised coating should be repaired with zinc rich paint to prolong the life of the barrier.

Damage after vehicle impact will need to be assessed on a case by case basis by a competent person, typically low angle impacts will not warrant barrier replacement. Significant impacts will mean damaged sections will need to be lifted out and replaced.

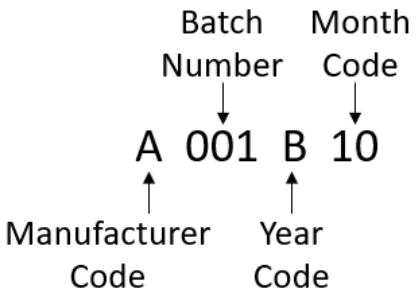
Recycling

HighwayGuard™ barrier and its T-Connectors are steel manufactured and this is commonly recyclable around the world. It may be necessary to remove T-Connectors to split HighwayGuard™ assemblies into 6m barrier sections only – contact authorised recycling centres for guidance.

Traceability

HighwayGuard™ is supplied with a small permanent sticker identifying product name and website - example below;

In addition, barrier section & T-connectors are serialised with the following format;



Contact Highway Care for further information.

Permanent Applications

For permanent applications the following conditions apply;

- M24 threaded bar with resin is recommended for anchoring.
- After initial installation it is recommended that the site is revisited after 1 month for inspection. After this it is recommended a thorough inspection is carried out every 5 years.

Refer to drawing HG-60-12 – HighwayGuard Foundation Details (extract Shown in manual appendix) for further information.

Frequently Asked Questions

1) What type of equipment is required to install HighwayGuard™?
Suitable lifting equipment such as a Franna crane with hook lifting chains, marking and drilling equipment (e.g. Hilti or compressed air rock drill) and a magnetic socket. Please refer to the tools and lifting equipment section.

2) What other barriers can HighwayGuard™ attach to?
There is a tested transition to Highway Care BG800™ from the HighwayGuard™ LDS system.

3) On average, how long does it take to install HighwayGuard™?
Depending on the application and circumstances at the site install times can vary. Factors such as experience of the workforce, equipment available, pre-assemble taken place, type of ground conditions can all affect installation time. It is possible to install a trailer with twelve 12m assemblies in under 20 minutes.

4) What testing has HighwayGuard™ been approved to?
HighwayGuard™ has been tested to the American standard MASH at TL-3 & TL-4. Please see the testing section for further details.

5) Can HighwayGuard™ be installed in any temperature/humidity environment?
HighwayGuard™ can be installed in the majority of environments. Large temperature swings may make it desirable to use the slotted anchor points to allow barrier movement.

6) What maintenance does HighwayGuard™ require?

HighwayGuard™ is a low maintenance barrier system that requires minimal maintenance. See the maintenance and permanent applications section of this manual for further details.

7) What is the expected lifespan of HighwayGuard™?
HighwayGuard™ has an expected lifespan of over 20 years. This is dependent on maintenance regime and site specific environment.

8) I need to achieve a really low deflection as I am working with limited space, what are my options?
HighwayGuard™ Lowest Deflection System (LDS) might be the best option for this application. With the increased anchor intervals at 12m spacing deflection is reduced. Contact Highway Care for further information.

9) I want to install HighwayGuard™ on a bridge deck, is this possible?

HighwayGuard™ can be installed on bridge decks in both permanent and temporary situations.

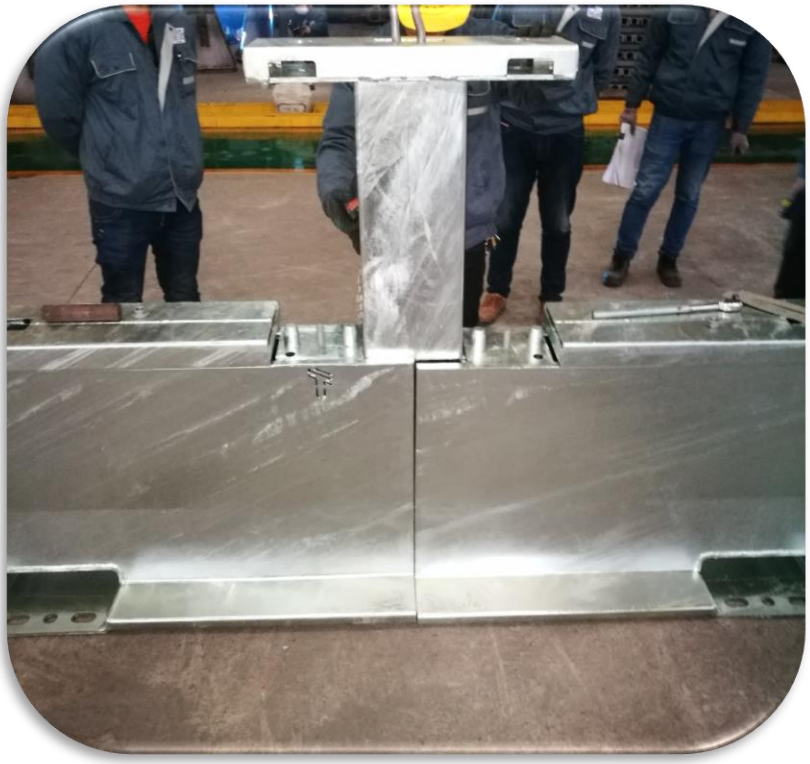
Depending on the project it may be possible to anchor either side of the bridge deck expansion joints.

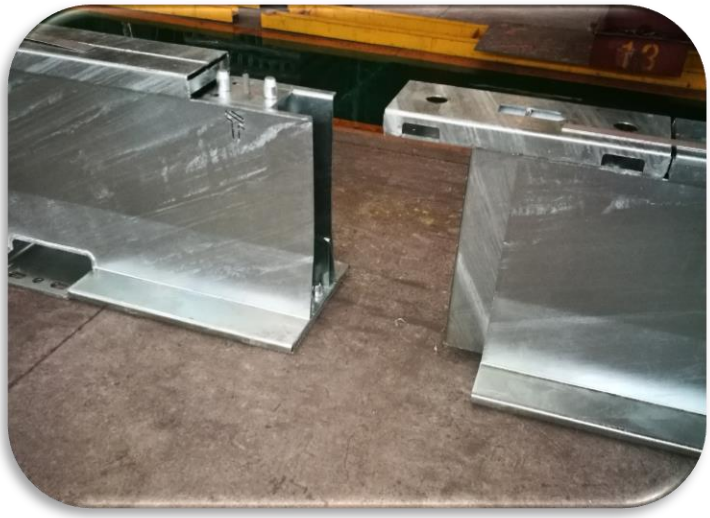
Where anchoring on the bridge deck is required, it may require project specific anchor details and possibly a variable length HighwayGuard™ section for the bridge expansion joint.

10) How close to excavations can it be placed?
For standard system installation, the barrier should be placed 1.93m away from excavation to match the tested deflection. For installation in AASHTO the barrier should be placed 1.71m away to match the tested deflection.

Appendix

Photo Examples





Risk Assessments

Hazard	Scenario	Precautions to minimise the risk	Method
Injury to head	Loading and unloading barrier Manoeuvring barrier Installing barrier	Use of PPE (hard hats) Competent crane operator/banksman Operative to be vigilant	Instruction Training Training
Injury to hands	Loading and unloading barrier Manoeuvring barrier Installing barrier	Use of PPE (gloves) & correct tools Competent crane operator/banksman Operative to be vigilant	Instruction Training Training Training
Injury to feet	Loading and unloading barrier Manoeuvring barrier Installing barrier	Use of PPE (safety boots) Competent crane operator/banksman Operative to be vigilant	Instruction Training Training
Load slipping from crane	Loading and unloading barrier Manoeuvring barrier	Use certified approved slings/lift equipment Competent operative	Inspection Training
Uncontrolled Load	Loading and unloading barrier Manoeuvring Barrie	Use correct tag rope Competent operators Establish correct safety zones	Training Training Training
Slinger falling from vehicle/load	Loading and unloading barrier Manoeuvring barrier Installing barrier	Safe access and egress to vehicle and load Operative to be vigilant	Training Training
Injury from site traffic	Loading and unloading barrier Manoeuvring barrier Installing barrier	Correct site management procedures Operatives to be vigilant	Training Training
Injury from traffic	Loading and unloading barrier Manoeuvring barrier Installing barrier	Correct traffic management procedures Operatives to be vigilant	Training Training

Working on a Live Carriageway

When working on a live carriageway, a safety zone is required between the working area and the live traffic lane. It is not possible to install HighwayGuard™ unless such a safety zone is provided. It is suggested that a minimum area of not less than 0.5 metres will be required between the HighwayGuard™ and the safety zone.

Coring/Drilling for installation of anchor system

Hazard	Precautions to minimise the risk	Actions
Electrocution Damage to underground services	Before installation procedure: Inspect service plans; Use cable locating equipment and mark the position of underground apparatus. Inspect drill & drill bit	Training
Injury to eyes	Use of PPE (goggles)	Training
Injury to ears	Use of PPE (ear defenders)	Training
Dust inhalation	Use of PPE (dusk mask)	Training
Injury to skin from chemical anchor resin	Use of PPE (gloves)	Training
Injury from traffic	Correct traffic management procedures followed and operatives to be vigilant	Training

Righting Inverted Units/Inverting Units

Hazard	Precautions to minimise the risk	Actions
Load slipping	Use certified slings Use competent slinger	Inspection Training
Injury to heads	Use of PPE (hard hat)	Instruction
Injury to feet	Use of PPE (steel toe capped safety boots)	Instruction
Injury to legs	Undertake operation in safe restricted area under control of competent banksman and crane operator	Training & Instruction
Death or injury as a result of manoeuvring truck	All truck movements under control of competent banksman	Training
Injury from collision with passing traffic	Correctly installed traffic management	Training

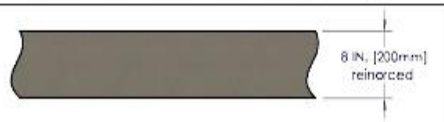
Installation Checklist Example

Installation Checklist				Barrier Run Information		
	Print Name	Sign Name	Date	Location;		
Installed by;				Number of runs;		
Inspected by;				Overall Length;		
				Project Number;		
HighwayGuard™				**Applicable Section; Yes or No**		
Is the site suitable for HighwayGuard™?				Yes	N/A	No
Are the pavement conditions suitable?				Yes	N/A	No
Are the anchors selected suitable for the pavement condition?				Yes	N/A	No
Are all the components available?				Yes	N/A	No
Are any crash cushions installed correctly?				Yes	N/A	No
Are the start and end of the barrier run installed correctly with all 6 anchors installed?				Yes	N/A	No
Are all the QuickLink security nuts installed?				Yes	N/A	No
Has any intermediate anchoring been used? If so, note the spacing here_____				Yes	N/A	No
Check there are no snagging points (more than 10mm)				Yes	N/A	No
Delineators installed?				Yes	N/A	No

HG-60-12 drawing extract

Anchor Specification		
	Drop In Pin	Resin Threaded Bar
Anchor Diameter	Ø30mm (1 3/16")	Ø24mm (1")
Drill Diameter	Ø32mm (1 1/4")	Ø28mm (1 1/8") to Ø32mm (1 1/4")

Anchoring Details						
System Type	Standard System TL3 & TL4					
Foundation Type	(1)	(2)	(3)	(4)	(5)	(7)
Drop in Pin Embedment	350mm (14")					500mm (20")
Resin Threaded Bar Embedment	300mm (12") MIN			150mm (6") MIN		N/A

Foundation Specifications		
Foundation Type	Description	Image
(1)	150mm (6") minimum asphalt depth	
(2)	50mm (2") minimum asphalt depth above an appropriately compacted DGA subbase	
(3)	50mm (2") minimum asphalt depth above a minimum of 150mm (6") reinforced concrete subbase	
(4)	200mm (8") minimum concrete depth if reinforced	
(5)	250mm (10") minimum concrete depth if nonreinforced	
(6)	200mm (8") minimum compacted DGA subbase	
(7)	400mm (16") minimum AASHTO Grade B Soil-Aggregate or equivalent soil properties	

Anchor Types

BG-21-1020 & BG-21-1022

Drop In Pin 30mm (1 3/16"): BG-21-1022 - Embedment Depth 350mm(14"), BG-21-1020 - Embedment Depth 500mm(20")
Hole Size: BG-21-1022 - 32mm (1 17/64") x 400mm (16") Deep, BG-21-1020 - 32mm (1 17/64") x 550mm (22") Deep
Shank Material - BS 970 Part 1: 1998 080M40
Plate Material - BS EN 10025-2:2004 S235JR
When installing in foundation type 7 the pin MUST be driven with no hole drilled.

TL3

M24 (1") x 330mm (13") Resin Threaded Bar Grade 8.8
Assembled with a M24 (1") Galvanised Washer and a M24 (1") Nut
- Use with a suitable Chemical Resin Anchor. 300mm (12") Embedment.
Drill Diameter Determined By Manufacturer.

TL4

M24 (1") x 450mm (18") Resin Threaded Bar Grade 8.8
Assembled with a M24 (1") Galvanised Washer and a M24 (1") Nut
- Use with a suitable Chemical Resin Anchor. 400mm (16") Embedment.
Drill Diameter Determined By Manufacturer.

Asphalt Specifications

For an asphalt surface to be a suitable foundation for anchoring HighwayGuard, the asphalt must be of or better than grade AR-4000 (As per ASTM d3381 '83) with 19mm (0.75") (type A or B) Maximum Aggregate.

Concrete Specifications

For a concrete surface to be a suitable foundation for anchoring HighwayGuard, the concrete must have a minimum compressive strength of 28 MPa (4000 PSI) with 19mm (0.75") (type A or B) Maximum Aggregate.

DGA Specifications

For a DGA (Dense Graded Aggregate) subbase surface to be a suitable foundation for anchoring HighwayGuard, the DGA must be better than grade AR-4000 (As per ASTM d3381 '83) with 19mm (0.75") (type A or B) Maximum Aggregate.
For anchoring requirements the minimum recommended depth of the subbase is 150mm, subbase should be sized upon road requirements

AASHTO Specifications

AASHTO Grade B Soil-Aggregate, 400mm (16In) minimum depth. In situ soil description (ASTM D2487) – AP40 Gravel with silty fines. Fill material description (ASTM D2487) & sieve analysis – AASHTO Grade B Soil-Aggregate. 400mm (16In) lifts tamped with a hydraulic compactor.