Earthquake resistant design of installations

Edition 1.1 EN / February 2014

Foreword

In recent years, the need to make allowance for the damage of equipment and installations by seismic actions has increased in importance worldwide.
As a result of the density of populations in town and city agglomerations as well as the high concentration of assets in industrialized states, the risk arising from earthquakes has greatly increased. This does not apply solely to “classical” earthquake regions, but also to Central Europe where, for example, the threat from earthquakes has been underestimated so far.
Greater efforts are necessary to reduce this risk.

This guideline provides the information needed by those carrying out design work for seismic restraint installations (non-structural building members) in field practice.
If, for example, chemical plants or infrastructure utilities, equipment, etc. are called to mind whose continued operation after an earthquake is of vital importance, e.g. hospitals, water supplies and telecommunication facilities, it becomes clear that material damage and consequential damage as well as that due to the breakdown or interruption of operations resulting from earthquake damage to non-structural elements can be extreme.
Despite the possibly serious damage that can be caused, the practical information available to engineers about this subject matter is limited. This guideline fills, so to speak, the gap in the respective technical literature.

Understandable design examples and actual solutions to seismic restraint installations have been given.
These make it possible for consulting engineers, planners, etc. to specify effective seismic restraint measures without them first having to carry out an unreasonable amount of design and calculation work.

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Title: **Earthquake resistant design of installations**

Version: 1.1 - EN

Summary: The document contains a guideline of seismic engineering and provides readily comprehensible information about seismic restraint design of installations.
The calculation is based on the EN 1998-1:2004 – Eurocode 8.
For the seismic design the seismic horizontal forces related to the seismic risk of the site are determinants, together with the specific factors of the building in question.
The seismic hazard in Europe varies significantly from site to site: as a consequence, seismic forces on installations may vary significantly.
Solutions proposed in this manual have been developed in order to cover the main applications and, at the same time, to meet the different levels of resistance required.
Installation systems for utilities, plants or equipment (nonstructural building members) equipped with seismic resistant bracing, allow to transfer the earthquake forces from the system to the main structure.

Place and date: Schaan, 31 January 2014

Contents

1. Introduction

In recent years, the consideration to the damage caused by an earthquake to non-structural elements of buildings has increased in importance worldwide.

Elements such as machinery, facades, interior decoration, piping and distribution lines, if designed only statically, generally are not able to support the additional horizontal forces resulting from a seismic event, even if with relatively low intensity.

The action of an earthquake may cause displacements of machinery, such as transformers or distribution substations, fall or breakage of pipes and power lines, with consequent induced risks even with high intensity, such as:
- propagation of fire or explosions due to the presence of flammable gases or electricity
- pollution or poisoning for the presence of dangerous fluids
- possible obstruction of escape routes
- loss of functionality of the utilities in buildings relevant to the public safety
- service interruption in productive buildings.

Several studies have shown that the cost of repairs resulting from a seismic event are largely affected by the damage suffered by non-structural elements, with rates sometimes much higher than the damage suffered by the structure of the building.

As a rule, the dead loads of items together with the working loads predominate in the case of load-bearing structures.
This applies also to non-structural fixtures, equipment, installations, etc. Often, when building components of this type as well as their fastenings are designed and installed, only the vertically acting forces due to weight are thus taken into account.
In many situations, as no continuous or variable forces are acting in a horizontal direction, the resistance to horizontal forces is often considerably smaller than to that in a vertical direction.
In view of this, the typical damage to buildings, structures, non-structural fixtures, equipment, installations, etc., caused by earthquakes must be attributed to the extraordinary effect of horizontal forces.

In the specific case of a hydraulic system, for example, the pipes are invested by horizontal forces due to a certain acceleration of the ground. Therefore, for the seismic design the seismic hazard of the site and specific factors relating to the building in question are crucial.

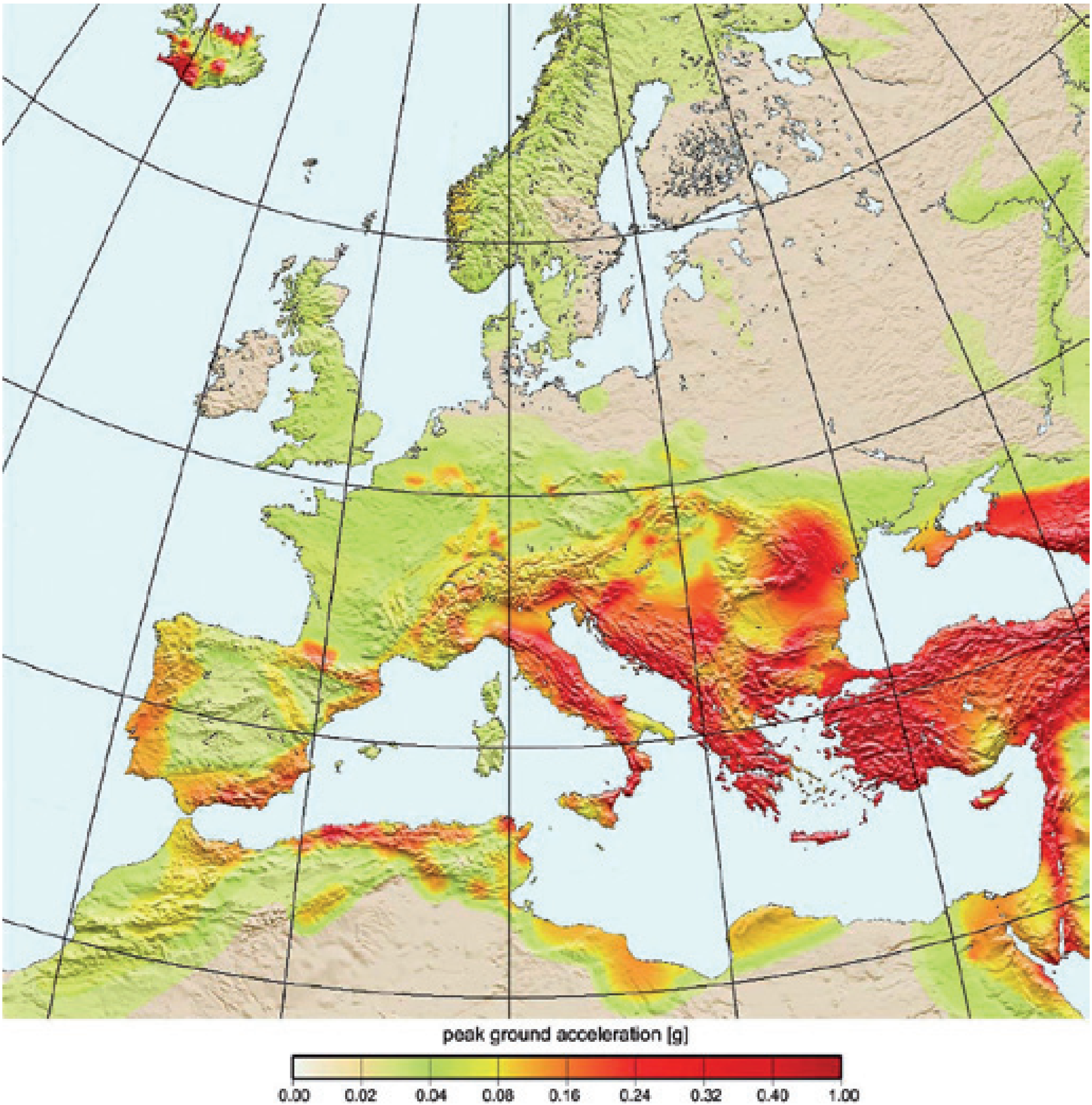
1.1 Seismicity in Europe

The following illustration (Fig. 1.1) provides an overview of seismicity and in turn the earthquake hazard in Europe.
The seismic hazard map shows the peak ground acceleration for stiff ground and 10% probability of exceedance in 50 years (475 year return period).

Seismic activity is particularly prevalent in the Mediterranean region - in Italy, the Balkans, Greece and Turkey.
Elevated levels of seismicity are also apparent in the Alps, on the Iberian peninsula and in parts of North Africa.
Northern Europe, and also Germany and France tend to have lower seismicity.
In Central Europe, a slightly elevated seismic hazard is particularly noticeable in the Rhine region.

Macro-seismic intensities and seismic hazards for each of the individual countries are shown in the national guidelines.

Fig. 1.1 – European seismic hazard map



1.2 Seismicity in Italy

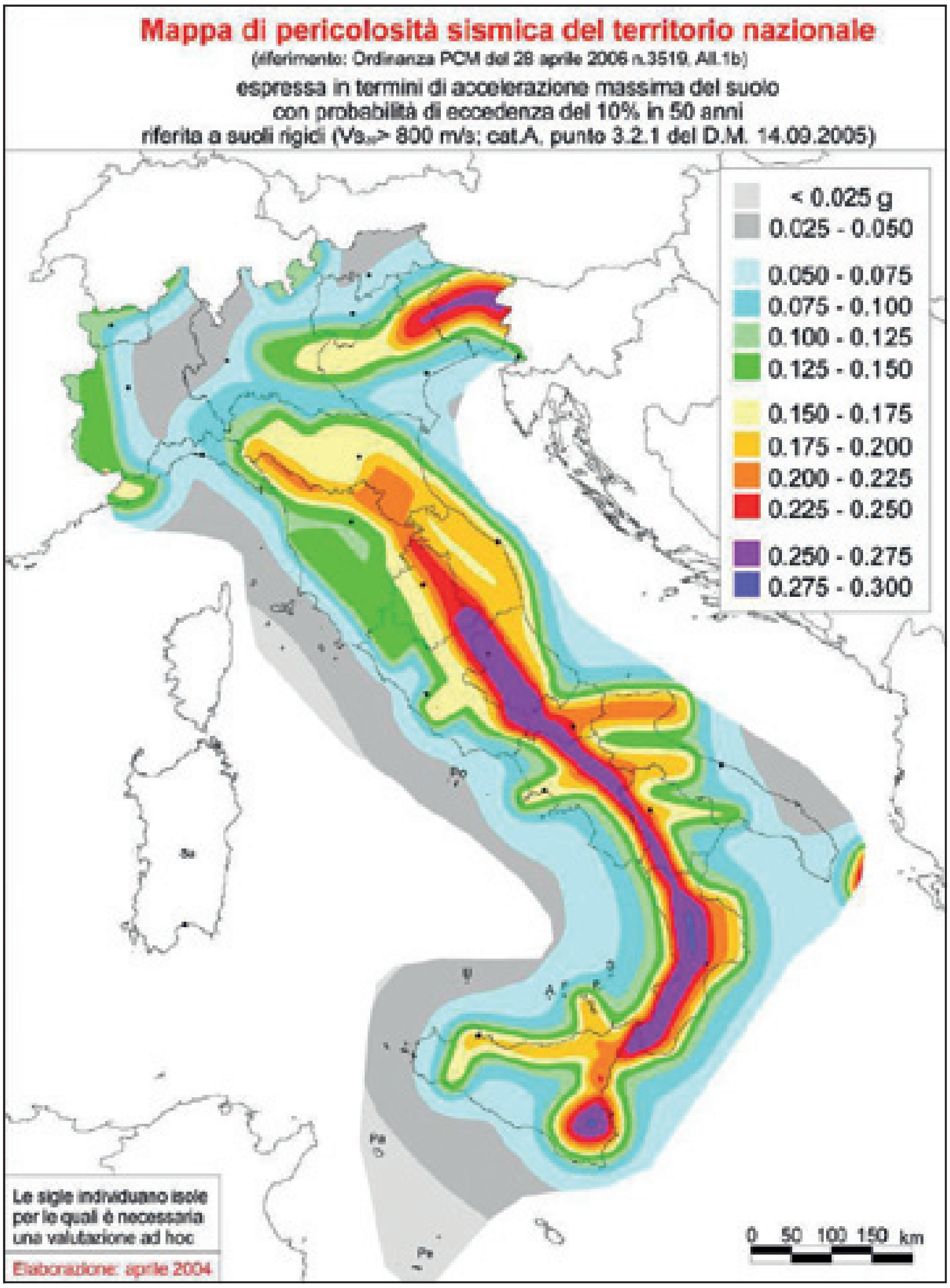
Italy is one of the most seismic countries in the Mediterranean area, both for the frequency of earthquakes that have historically affected his territory and for the intensity that some of them have achieved.

The figure below gives an overview of macro-seismic intensity in Italy. Intensity is a qualitative measure of earthquake strength. In contrast to the instrumentally determined magnitude, it is determined on the basis of human perception as well as the effects on the landscape and buildings (macroseismicity).

The physical values such as ground acceleration used to quantify the earthquake impact and which have to be used to calculate the earthquake resistance of the Hilti Mounting System MQS are described in Fig. 1.3.

Chapter 2 describes the calculation method for the determination of the seismic force according to the ground acceleration and the boundary conditions.

Fig. 1.2 – Maximum ground acceleration according to "Ordinanza PCM n. 3519 – 2006"



1.3 Code framework

1.3.1 Eurocodes

The European standards, known as Eurocodes, form a set of standards recognized as a high-quality, coherent construction standard. They can be implemented anywhere in the world thanks to the facility to add national annexes.
It should be noted that many countries use building codes based on earlier national standards (such as BS, DIN, NF).
As a consequence, these countries will be amending their standards.

1.3.2 National annexes

The national annex enables each member country to take into account their own local differences in geography, climate and individual conditions without detriment to the level of safety. Whenever the EN Eurocodes are used for a supporting framework or structure, the national annex for the country in which the supporting framework is to be erected is required.
The list of so-called NDPs (Nationally Determined Parameters) is given in the preface to each part of the EN Eurocode.

1.3.3 EN 1998, Eurocode 8

The EN 1998 series (Eurocode 8) deals with earthquake resistance. The standard is divided into different sections:
Part 1 of Eurocode 8 – the EN 1998-1 standard[1)] – applies to the design of structures in building and structural engineering in earthquake areas. The standard is subdivided into 10 sections, of which a number are specifically dedicated to the design of buildings. They contain the fundamental performance requirements and compliance criteria applicable for design of structures in building and structural engineering in earthquake areas.

In addition to EN 1998-1, supplementary rules are necessary for certain types of supporting framework which are dealt with in EN 1998-2 to EN 1998-6: They are contained in these sections of Eurocode 8:
• EN 1998-2 contains special regulations for bridges;
• EN 1998-3 contains regulations for the assessment and improvement of earthquake resistance of existing buildings;
• EN 1998-4 contains special regulations for silos, storage tanks and pipelines;
• EN 1998-5 contains special regulations relating to foundations, retaining structures and geotechnical aspects;
• EN 1998-6 contains special regulations for towers, masts and chimneys.

[1] EN 1998-1:2004 Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings

2. Calculation of seismic actions

2.1 Non-structural elements

Installations and fittings that do not form part of the supporting framework of buildings are described as nonstructural elements. Non-structural elements are building claddings, facades or suspended ceilings.
Installations and equipment such as pipelines, apparatus and machinery and machines or photovoltaic installations are also designated as non-structural elements.

If non-structural elements have to be designed and secured so as to be earthquake resistant, the decisive factor for the design and dimensioning is not the movement of the ground (ground acceleration $\mathbf{a_g}$) but that of the building or floor. Here the decisive floor acceleration $\mathbf{a_f}$ is dependent on the building, which transmits the floor movements during an earthquake (Fig. 2.1).
The building support structure amplifies the ground vibrations, especially in the area of the building's natural frequency and acts like a frequency filter.

A dynamic amplification is also brought about by the non-structural element itself. Here, the decisive factor is the natural vibration behaviour of the element itself, its damping characteristics and its ability to dissipate energy through plastic deformation.

2.2 Equivalent static analysis

The above-mentioned relationships involve complex dynamic processes which can be measured with elaborate dynamic calculations. Simulations of the type are however costly, for which reason this technique is only used to demonstrate the earthquake resistance of non-structural elements in exceptional cases, such as for nuclear power station components.

Non-structural elements are normally measured using the so-called equivalent static force method.
In this case, an equivalent static force (seismic force) $\mathbf{F_a}$ acting on the element's centre of gravity is determined.

The building and element vibrations as well as the ability of the element to absorb energy through deformation (energy dissipation) are taken into account by means of factors (coefficients).

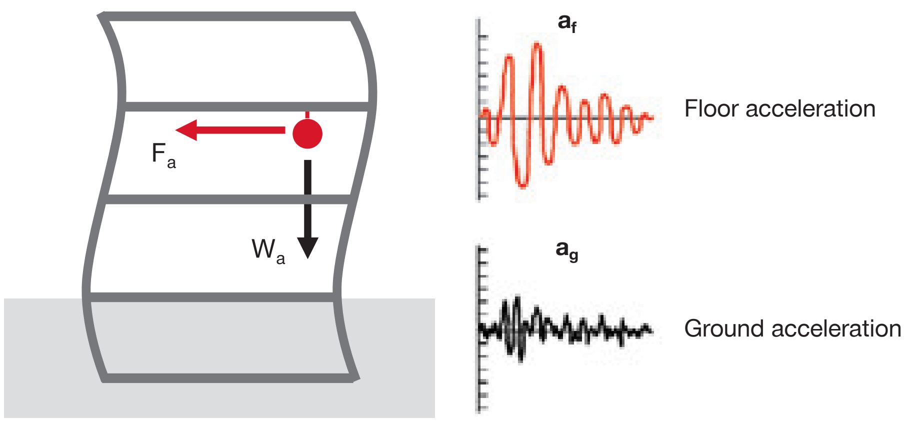


Fig. 2.1
Equivalent static analysis for the determination of earthquake actions on non-structural elements

2.3 Calculation of seismic actions in accordance with EC8

2.3.1 General form

According to EN 1998-1, the horizontal seismic force (equivalent static force) $\mathbf{F_a}$ acting on a non-structural element at the centre of mass, is calculated as follows:

$$F_a = \frac{\gamma_a}{q_a} \cdot S_a \cdot W_a$$

where:

F_a	horizontal seismic force	[kN]
W_a	weight of the non-structural element	[kN]
S_a	seismic coefficient of the non-structural element	[-]
γ_a	importance factor of the non-structural element	[-]
q_a	behaviour factor of the non-structural element	[-]

2.3.2 Importance factor

The importance factor $\boldsymbol{\gamma_a}$ takes into account the importance of the building. It is not a physical value, but a risk-oriented factor, that is to say a safety factor. Eurocode 8 provides four categories of importance. In the national standards, these are designated as building categories or building classes.

For normal buildings, the importance factor $\boldsymbol{\gamma_a}$ = 1.0 applies. For schools, shopping centres and administrative buildings, the factor $\boldsymbol{\gamma_a}$ = 1.2 must be used. The importance factor $\boldsymbol{\gamma_a}$ = 1.4 is to be used for buildings such as hospitals or for other vitally important buildings in the event of an emergency (fire brigade buildings for example).

Table 2.1 – Importance factor $\boldsymbol{\gamma_a}$ for building (load-bearing structure) according to building class or category (BWK)

BWK	Characteristics	Examples	γ_a
I	Only occasionally occupied by people Minimal importance for public safety	• Agricultural buildings	0.8
II	No major gatherings of people No especially valuable goods and installations No danger to the environment	• Residential, office, retail, industrial, warehouse buildings • Garages	1.0
III	Large gatherings of people likely Especially valuable goods and installations Important infratructural function Limited danger to the environment	• Hospital including systems and installations if not in BWK III • Shopping centres, sports stadiums, cinemas, theatres, schools, churches • Public administration buildings • Supply, waste disposal and telecommunications buildings	1.2
IV	Vital infrastructural function Significant danger to the environment	• Acute hospitals including systems and installations • Emergency services buildings, systems and installations (e.g. fire brigade) • Viral buildings for supply, waste disposal, telecommunications	1.4

For non-structural elements, the importance factor $\boldsymbol{\gamma_a}$ is generally irrelevant ($\boldsymbol{\gamma_a}$ = 1.0).
Additional safety, i.e. an importance factor $\boldsymbol{\gamma_a}$ > 1.0 need only be used if the element is important for the function of vital systems (life lines) or if the element may pose major risks in the case of earthquake damage.
EN 1998-1:2004 states that the importance factor γa may not be lower than 1.5 for the following non-structural elements:
• Anchoring of machines and equipment required for life-saving systems
• Storage tanks and containers holding toxic or explosive substances that pose a danger to the public
In all other cases, an importance factor of 1.0 is to be used for non-structural elements.

2.3.3 Behaviour factor

The ductility of elements and thereby the reduction of the seismic forces acting on these parts is described in the measurement by the behaviour factor $\mathbf{q_a}$. As a basic principle, in order to use a behaviour factor of $\mathbf{q_a}$ > 1.0 at the ultimate limit state, the scope for energy dissipation must be demonstrated and quantified. It is however difficult to demonstrate the dissipative capacity of elements and not possible in practice without time-consuming practical tests and analyses. EN 1998-1:2004 sets out the maximum values for behaviour factor $\mathbf{q_a}$ to be used for non-structural elements in the following table.

Table 2.2 – Behavior factor $\mathbf{q_a}$ for non-structured elements in accordance with EN 1998-1:2004

Type of non-structural element	q_a
• Overhanging balustrades or decorative elements • Signs and advertising hoardings • Chimneys, masts and storage tanks on support that act as non-trussed cantilever beams over a length of more half than their overall height	1.0
• External and internal walls • Partition walls and facade components • Chimneys, masts and storage tanks on support that act as non-trussed cantilever beams over a length of more half than their overall height or that are stiffened or guyed against the supporting framework, and that is to say at the height of or above the centre of mass • Anchorages for permanently available cupboards and piles of books on the floor • Anchorages for suspended ceilings and light fittings	2.0

Information on the magnitude of the behaviour factor can be found in other places including Part 4 of Eurocode 8 (EN 1998-4) which applies to silos, storage tanks and pipelines. Information is available on the behaviour factor for welded steel pipelines that exhibit considerable deformation and dissipation capacity provided they are sufficiently thick. In this case, a behaviour factor $\mathbf{q_a}$ = 1.5 - 3.0 is indicated, depending on the pipe geometry. Experimental investigations into energy dissipation of steel cantilever constructions show that the behaviour factor for mounting constructions of this nature is usually $\mathbf{q_a}$ = 1.5 - 2.5.

2.3.4 Seismic coefficient

EN 1998-1:2004 requires that the seismic coefficient $\mathbf{S_a}$ be determined on a location-specific basis as follows.
It is determined from the seismic hazard and the amplification factor (see below).

$$S_a = \frac{a_g}{g} \cdot S \cdot \left[3 \cdot \frac{(1 + z/H)}{1 + (1 - T_a/T_1)^2} - 0.5\right] = \frac{a_g}{g} \cdot S \cdot A$$

S_a	seismic coefficient of the non-structural element	[-]
a_g	design ground acceleration for type A ground	[m/s^2]
S	soil factor	[-]
z	height of the non-structural element (from the building foundation level)	[m]
H	height of the building (from the building foundation level)	[m]
T_a	fundamental vibration period of the non-structural element	[s]
T_1	fundamental vibration period of the building (in the direction concerned)	[s]
A	amplification factor	[-]

2.3.5 Seismic hazard

The term contained in the equation for the seismic coefficient $\mathbf{S_a}$ of the non-structural element

$$\frac{a_g}{g} \cdot S$$

takes into account the design ground acceleration $\mathbf{a_g}$ and the soil factor **S**, thereby describing the seismic hazard at a particular location.

The design ground acceleration $\mathbf{a_g}$ is determined on a country by country basis according to the local seismic hazard and may be found in the relevant national annex to EN 1998-1 (EN 1998-1/NA) or in the national guidelines.

According to EN 1998-1:2004, ground classes A, B, C, D and E can be described in the following table.
The recommended soil factor **S** for these ground classes is also given in this table. In order to take account of the influence of local building and subsoil conditions, the parameter values in a particular country may also be specified in the national annex. In this case, the ground classification scheme specified in the national annex taking into account the subsurface geology of an individual country also contains a definition of the soil factor **S**. If the influence of the subsurface geology is not taken into account, EN 1998-1:2004 recommends the use of two response spectra (type 1 and type 2).
If the earthquakes which essentially define the seismic hazard in a particular location have surface wave magnitudes $\mathbf{M_s}$ not exceeding 5.5, use of the type 2 spectrum is recommended.

Table 2.3 – Recommended ground class and soil factor **S** according to EN 1998-1:2004

Ground class	Description	Reccomended soil factor S according to EN 1998-1:2004	
		Response spectrum type 1	Response spectrum type 2
A	Rock or similar rock-like geological formation, with no more than 5 m of softer material on the surface	1.00	1.00
B	Deposits of very dense sand, gravel of very stiff clay, with a thickness of at least a few tens of metres, characterised by a gradual increase in mechanical properties with increasing depth	1.20	1.35
C	Deep deposits of dense or medium density sand, gravel or stiff clay, with thicknesses of between a few of metres to several hundred metres	1.15	1.50
D	Deposits of loose to medium density non-cohesive soil (with or without a few soft cohesive layers), or predominantly soft to stiff cohesive soil	1.35	1.80
E	A soil profile consisting of a surface alluvial layer with $\mathbf{v_s}$ values as per C or D and variable thickness between around 5 m and 20 m above stiffer soil material with $\mathbf{v_s}$ > 800 m/s	1.40	1.60

2.3.6 Amplification factor A

The amplification factor **A** is used to take into account the amplification in acceleration of the non-structural element with increasing height (**z/H**) as well as the amplification through the element itself attributable to the fundamental vibration period of the non-structural element ($\mathbf{T_a}$) and fundamental vibration period of the building ($\mathbf{T_1}$).

$$A = \left[3 \cdot \frac{(1 + z/H)}{1 + (1 - T_a/T_1)^2} - 0.5\right]$$

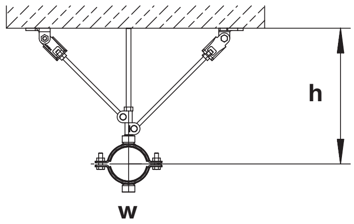
Non structural elements like equipment and machines, in particular comparatively small and light components, are compared to building much more stiffer: ratio $\mathbf{T_a / T_1}$ in that case is very small and it is tolerable to set it zero ($\mathbf{T_a / T_1} \cong 0$) to determine the static substitute load. Please refer to the **Annex F** for more details.

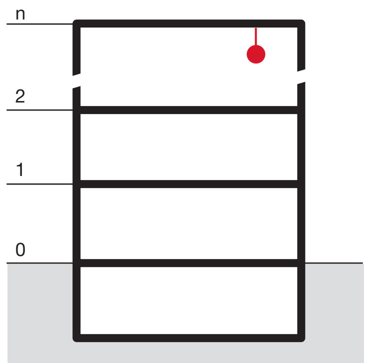
Based on the assumption above, the amplification factor **A** could vary between these values:
- non-structural element in the foundation of the building (**z/H** ≅ 0): A = 1.0
- non-structural element on the roof of the building (**z/H** ≅ 1): A = 2.5

2.4 Numerical example

The section below is a simplified example of the calculation of the horizontal seismic force acting on a mass hanging from a concrete slab, considering a hypothetical case of an installation of a single pipe with mass **w** (kg/m) fixed at a distance **h** (m) from the ceiling. The objective is to identify the main parameters that influence the calculation of seismic force and obtain, finally, a real calculation according to the static analysis-equivalent.

2.4.1 Input





Pipe weight	**w** = 10 kg/m	(steel pipe DN50, full of water, with insulation)
Distance from ceiling	**h** = 0.25 m	(from intrados to the centre of gravity of the pipe)
Installation spacing	$\mathbf{i}_{\mathbf{static}}$ = 2.00 m	(distance between the pipe fastenings in the pipe run)

According to EC8, the horizontal seismic load is

$$F_a = \frac{\gamma_a}{q_a} \cdot S_a \cdot W_a$$

The seismic coefficient $\mathbf{S_a}$ must be determined on a country by country basis according to the local seismic hazard, taking account of the influence of local building and subsoil conditions (relevant national annex or in the national guidelines must be observed).

$$S_a = \frac{a_g}{g} \cdot S \cdot \left[3 \cdot \frac{(1 + z/H)}{1 + (1 - T_a/T_1)^2} - 0.5\right] = \frac{a_g}{g} \cdot S \cdot A$$

Assuming for example that:

$\mathbf{a_g}$ = 2.42 m/s^2	(example for a medium-seismicity area in Italy)
S = 1.35	(example for ground class B, spectrum type 2 – see table 2.2)
z/H = 1	(pipe installed on the top floor of the building – see picture above)
$\mathbf{T_a/T_1}$ ≈ 0	(see Annex F)

the seismic factor **A** is equal to 2.5 and, finally, the seismic coefficient $\mathbf{S_a}$ = 0.83

2.4.2 Evaluation of the horizontal seismic load

The importance factor γ_a and the behaviour factor can be assumed q_a as follow:

γ_a = 1 (non-structural element, without function for vital systems)
q_a = 2 (braced installation system – see Table 2.1)

So, the horizontal seismic force is

$$F_a = \frac{\gamma_a}{q_a} \cdot S_a \cdot W_a = \frac{1}{2} \cdot 0.83 \cdot w \cdot i_{seismic} = 0.415 \cdot 0.10\ kN/m \cdot i_{seismic} = 0.0415 \cdot i_{seismic}$$

where $i_{seismic}$ is the distance between supports with the same type of bracing – in this example, is the distance between two pipe supports with transversal bracing.
It is supposed to alternate the seismic support between transversal set-up and longitudinal set-up (see **Section 3.2** for more details on the bracings configuration in a pipe run):

$$i_{seismic} = 2 \cdot i_{static} = 4\ \text{m}$$

As a consequence, the seismic load acting on the braced pipe support is

$$F_a = 0.0415 \cdot i_{seismic} = 0.0415 \cdot 4 = 0.166\ \text{kN}$$

2.4.3 Evaluation of actions on seismic bracing

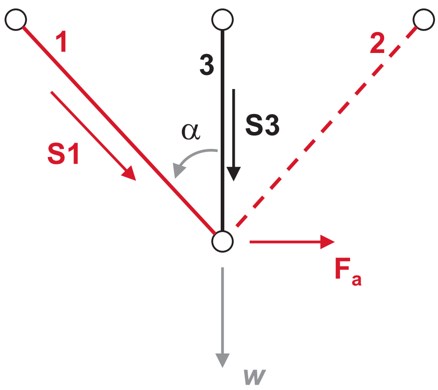
Considering the following structural scheme and neglecting the brace 2, subject to compression alone, it's possible to determine easily the seismic actions S1 and S3, acting on the brace 1 and the vertical rod respectively.

Assuming α = 45 ° we deduce

$$S1 = \frac{F_a}{\sin\ \alpha} = 0.235\ \text{kN}$$

$$S3 = W - \frac{F_a}{\tan\ \alpha} = w \cdot i_{static} - \frac{F_a}{\tan\ \alpha} = 0.034\ \text{kN}$$

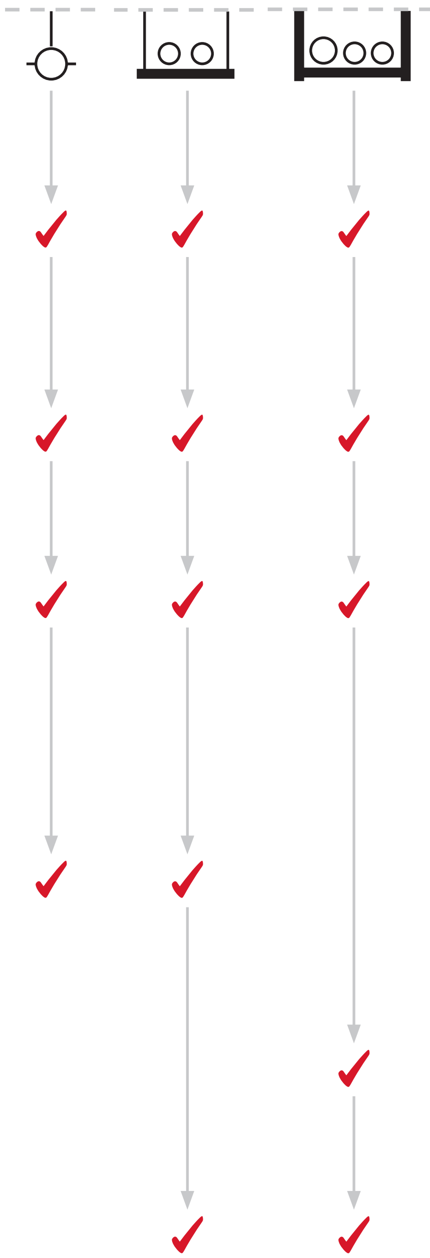
Fig. 2.2
Structural scheme of actions on seismic bracing

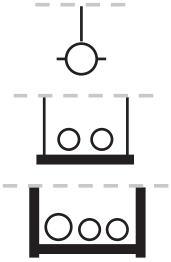


The brace 1 is therefore subject to a tensile force equal to 0.235 kN, considering the horizontal seismic load F_a = +0.166 kN.
It's evident that the seismic action, by definition, can act in both directions (± F_a).
As a consequence, brace 2 is necessary to absorb the horizontal seismic action in the opposite direction: F_a = -0.166 kN.
The vertical threaded rod is subject to a tensile force of 0.034 kN; in this case it is not necessary to stiffen the rod with any reinforcements (see **Annex E** for more details on the use of rod stiffeners).

3. Typical applications

3.1 Guide for the load capacity verification





Single pipe: points 1 ÷ 4

Trapeze with rods: points 1 ÷ 4 and 6

Trapeze with channels: points 1 ÷ 3 and 5

1 Calculation of horizontal seismic loading $\mathbf{F_a}$ (see **Chapter 2**) to get horizontal forces $\mathbf{E_x}$ and $\mathbf{E_y}$ (longitudinal and transversal). $\mathbf{E_z}$ can be neglected according EN 1998-1; 4.3.3.5.2 and 4.3.5.2.
$\mathbf{F_a / E_x / E_y}$ = design values

2 Choose – out of the typical collection – the actual load case:
Longitudinal / Transversal / 4-way

3 Consider/check on the boundary conditions, whatever is relevant for your particular applications:

- max H, max L	(see notes on Typicals)
- angle brace limitation	(**Annex A**)
- structural attachment	(**Annex C**)
- right pipe ring	(**Annex D**)
- rod stiffener requirement	(**Annex E**)

4 Compare actual load $\mathbf{F_a}$ with the max. design load $\mathbf{F_{horiz}}$ (longitudinal and transversal) mentioned on typical drawing:

$\mathbf{F_a \leq F_{horiz}}$ **(max. design load)**

5 Choose/Check suitable solutions in the Selection Tables (see **Annex B**)

6 Calculate horizontal channel separately:

CO1: γ_G x LC1 + γ_Q x LC2

CO2: LC1 + LC2 ± E_x ± 0.3E_y

CO3: LC1 + LC2 ± 0.3E_x ± E_y

a) check load case CO1 where γ_G =1.35; γ_Q =1.5;
b) check load case CO2
CO3 not needed ➔ CO2 is the worst case!

3.2 Situation of seismic bracings in a pipe run

Braces for a earthquake-resistant installation need to be arranged at a distance (b) from each other that must be assessed in relation to seismic acceleration, the mass of the pipes or (system in general) and the type of braces itself – i.e. the situation of the seismic brace respect to the main axis of the pipe.
For this reason, we can distinguish three basic types of seismic-resistant media:

- **Longitudinal bracing**: seismic brace arranged longitudinally to the main direction of the plant – resistance to horizontal actions acting along the main axis of the pipe
- **Transversal bracing**: seismic brace perpendicular to the main direction of the plant – resistance to horizontal actions acting transversely of the pipe
- **4-way bracing**: structure composed of both longitudinal and transversal braces, therefore able to withstand all of the forces acting on the horizontal plane.

It is advantageous for the bracing to be at a spacing that is a multiple of the normal pipe fastening spacing of (s), so that, for example, every third or fourth pipe fastening is braced.

Fig. 3.1
Bracing arranged transversely and longitudinally in relation to pipe axis and at spacing of b in each case

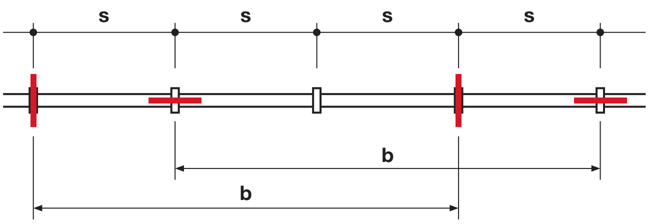
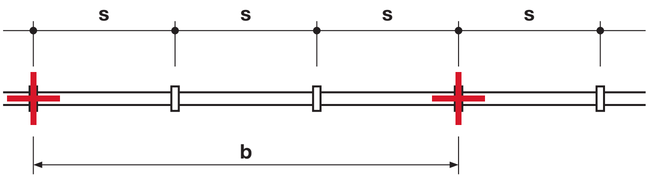


Fig. 3.2
Transversal and longitudinal bracing on the same pipe fastening – 4-way bracing



Where the pipe changes direction, particular care is necessary to ensure that bracing is not provided in one direction only (Fig. 3.3). In such cases it can sometimes be necessary to arrange identical sets of bracing one after another along the pipe axis (Fig.3.4).

Fig. 3.3
Inappropriate arrangement of bracing (none in y direction)

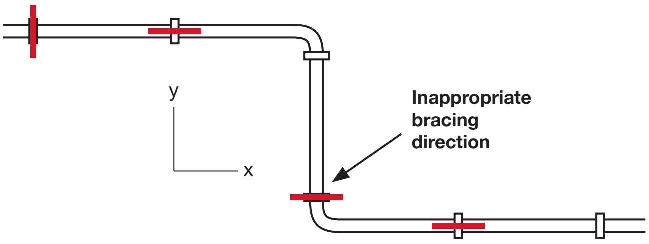
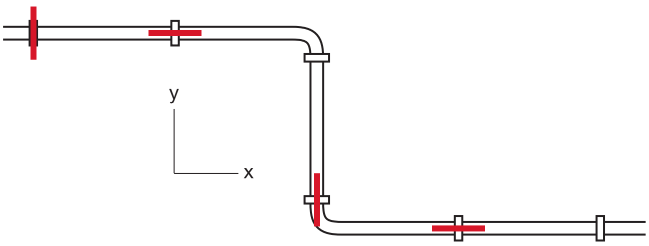
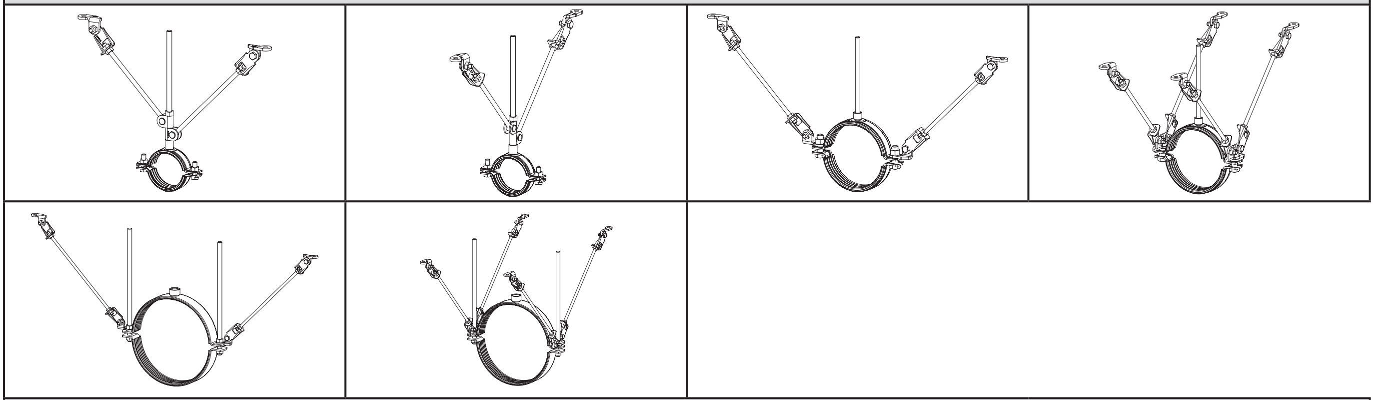


Fig. 3.4
Horizontal forces in y direction taken by longitudinal bracing

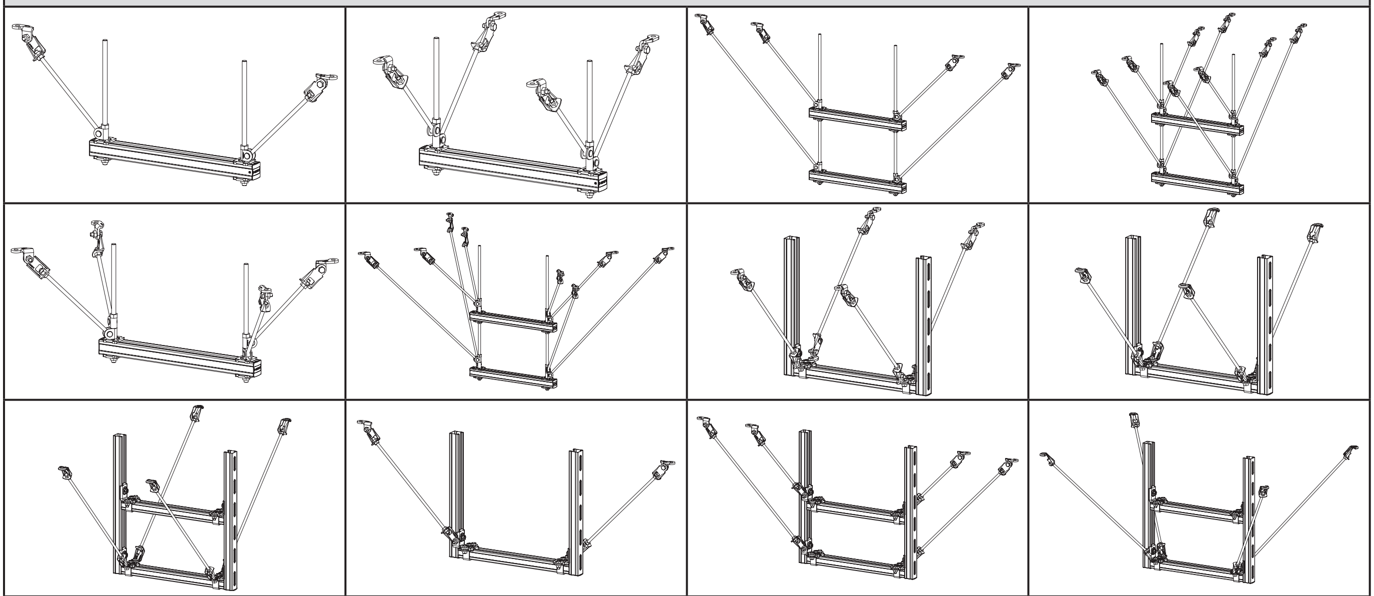


3.3 Collection of typical applications

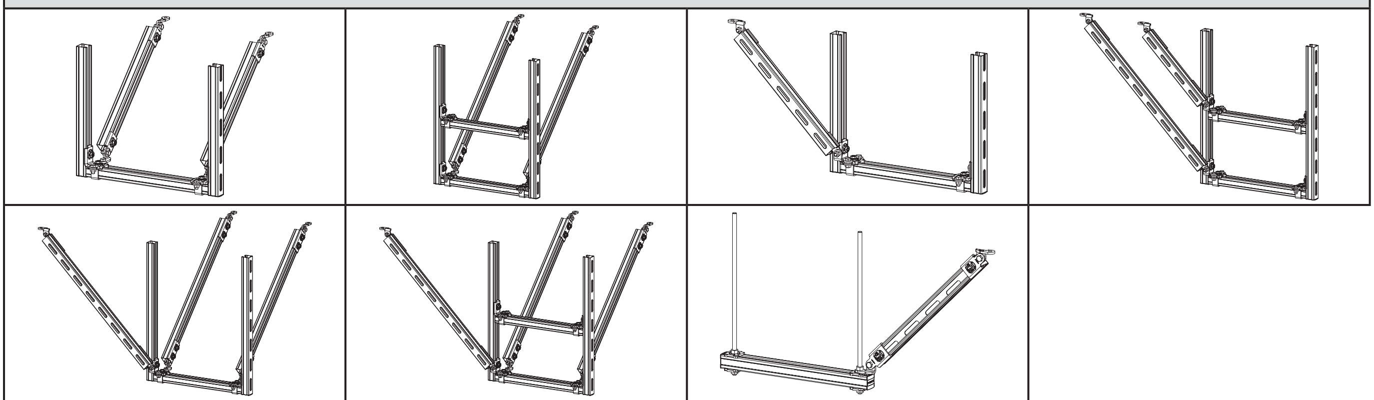
Single pipe



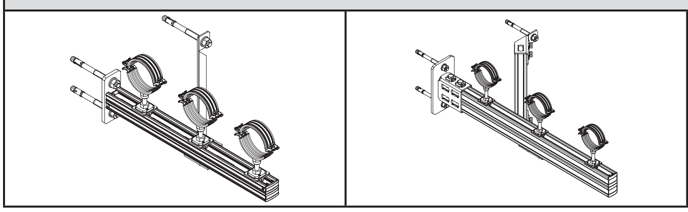
Trapeze – seismic bracing with rods



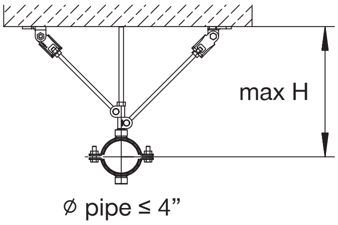
Trapeze – seismic bracing with channels

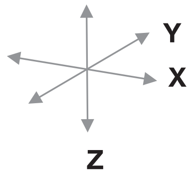


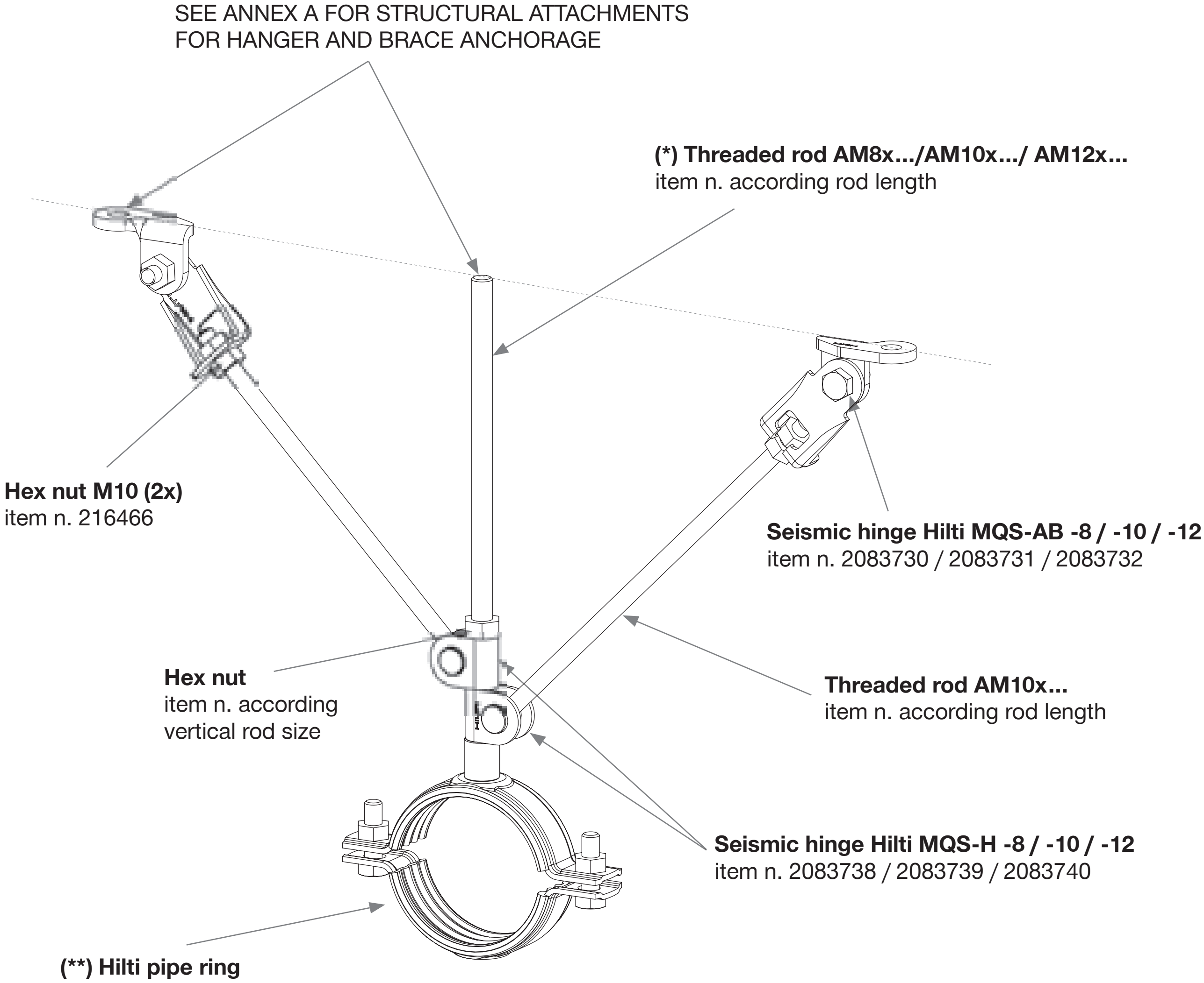
Wall bracket



Single pipe Transversal bracing	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 0 -	- 800 -







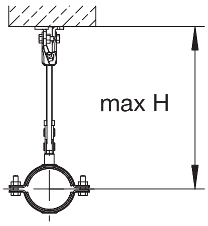
General Design Notes

Design loads are stated in this paper are depending on following conditions:

- (*) using M10 or M12 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

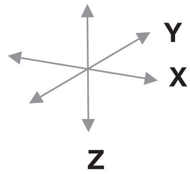
MQS System
Seismic Designed Solutions

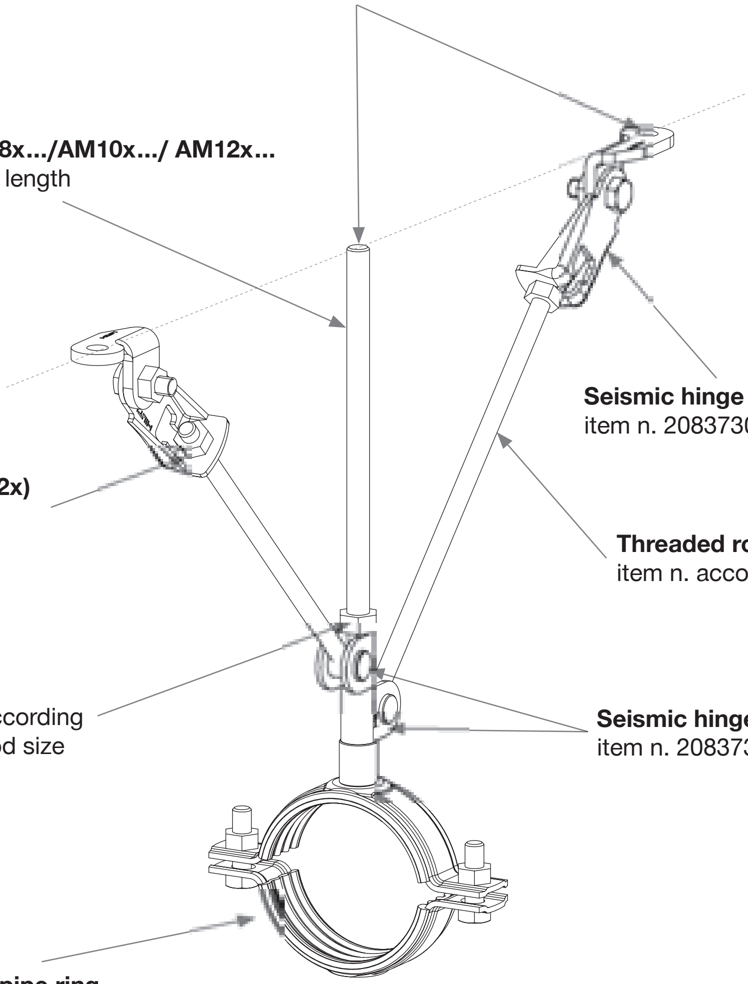
Single pipe Longitudinal bracing	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 800 -	- 0 -



ø pipe ≤ 4”

SEISMIC LOAD ORIENTATION

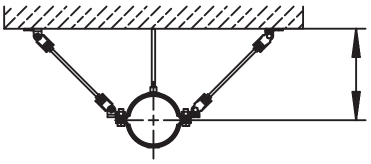




General Design Notes
Design loads are stated in this paper are depending on following conditions:
- (*) using M10 or M12 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

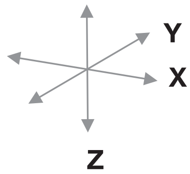
MQS System
Seismic Designed Solutions

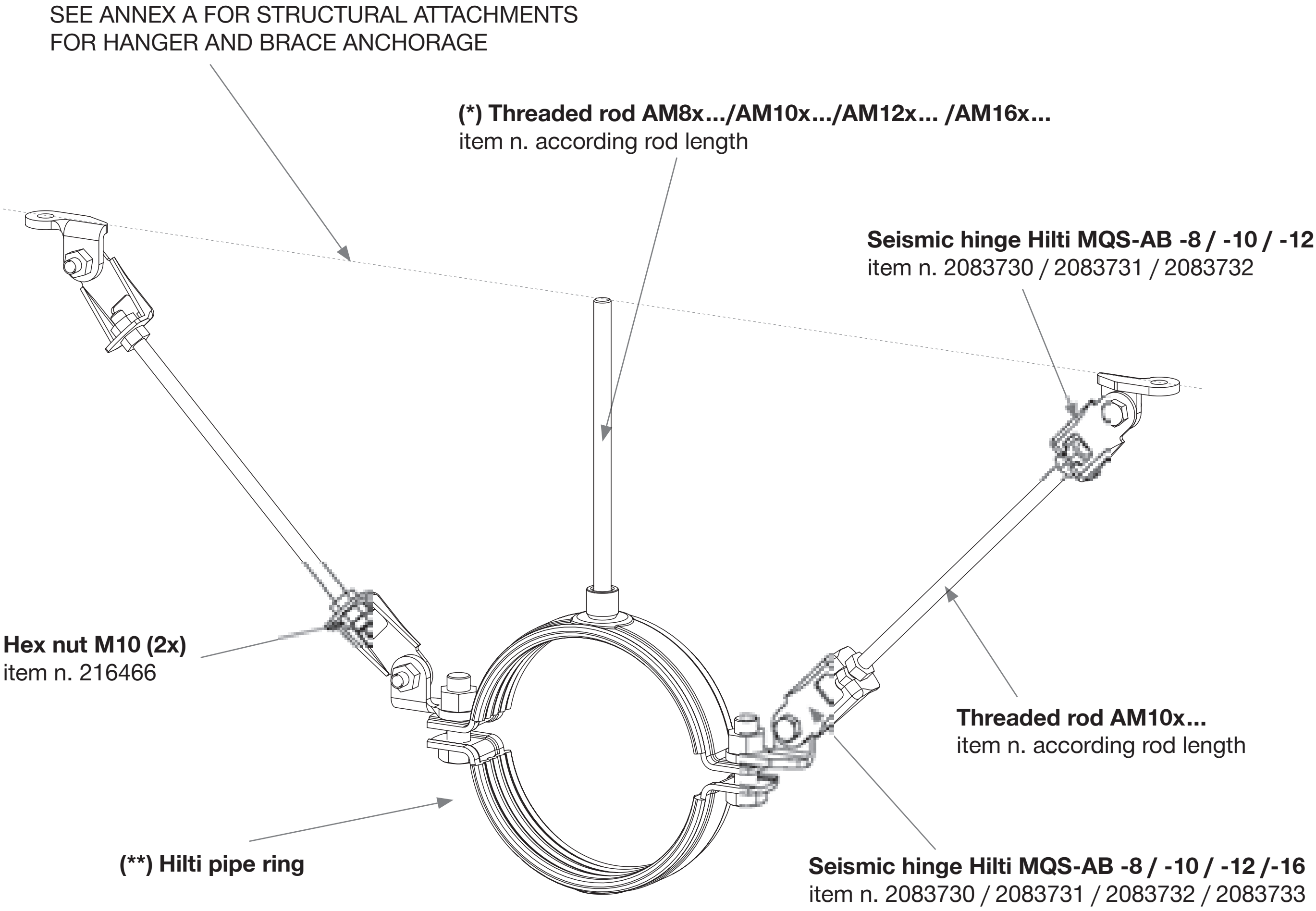
# Single pipe Transversal bracing	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	**Transversal [X]**
	- 0 -	- 1500 -



4” ≤ Ø pipe ≤ 324 mm

SEISMIC LOAD ORIENTATION





General Design Notes

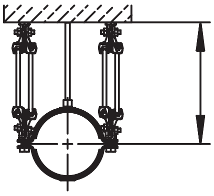
Design loads are stated in this paper are depending on following conditions:

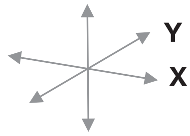
- (*) using M10, M12 or M16 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

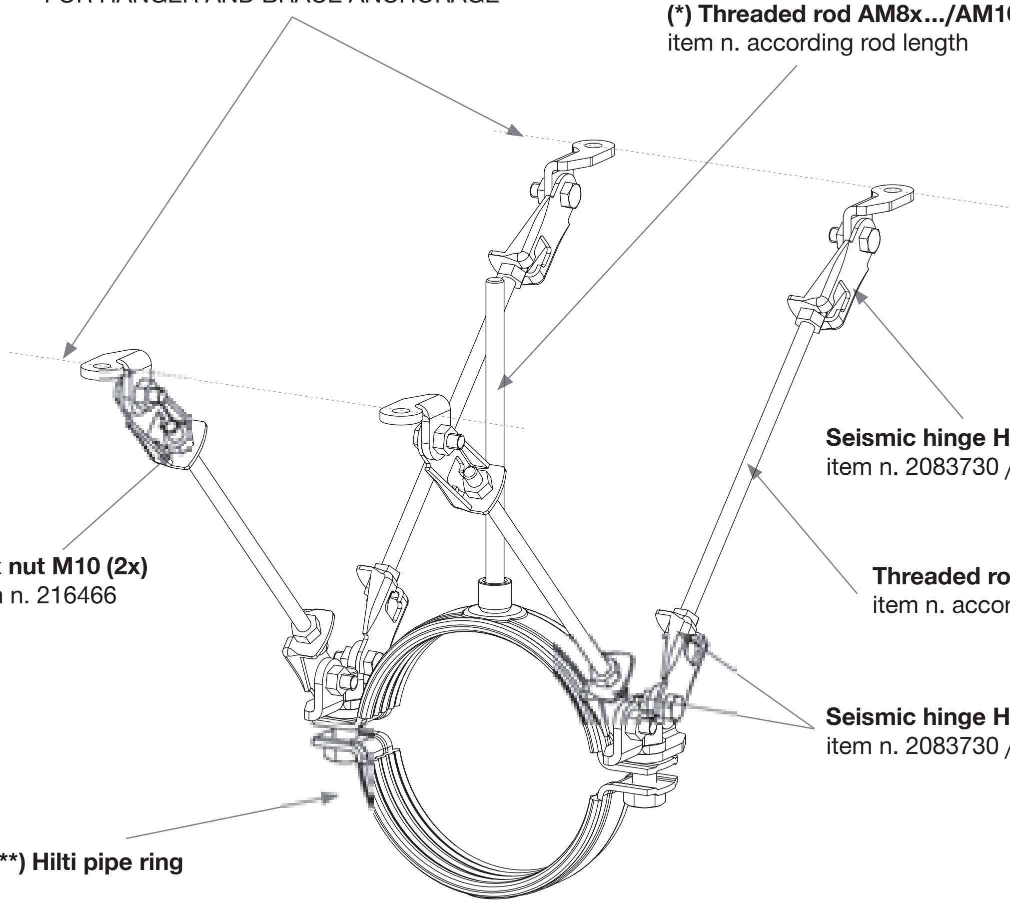
MQS System

Seismic Designed Solutions

Single pipe Longitudinal bracing	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 1500 -	- 0 -







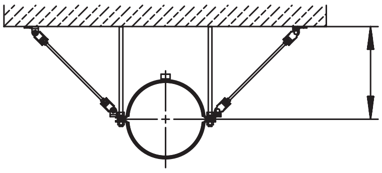
General Design Notes

Design loads are stated in this paper are depending on following conditions:

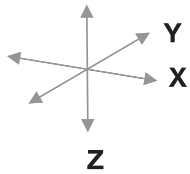
- (*) using M10, M12 or M16 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

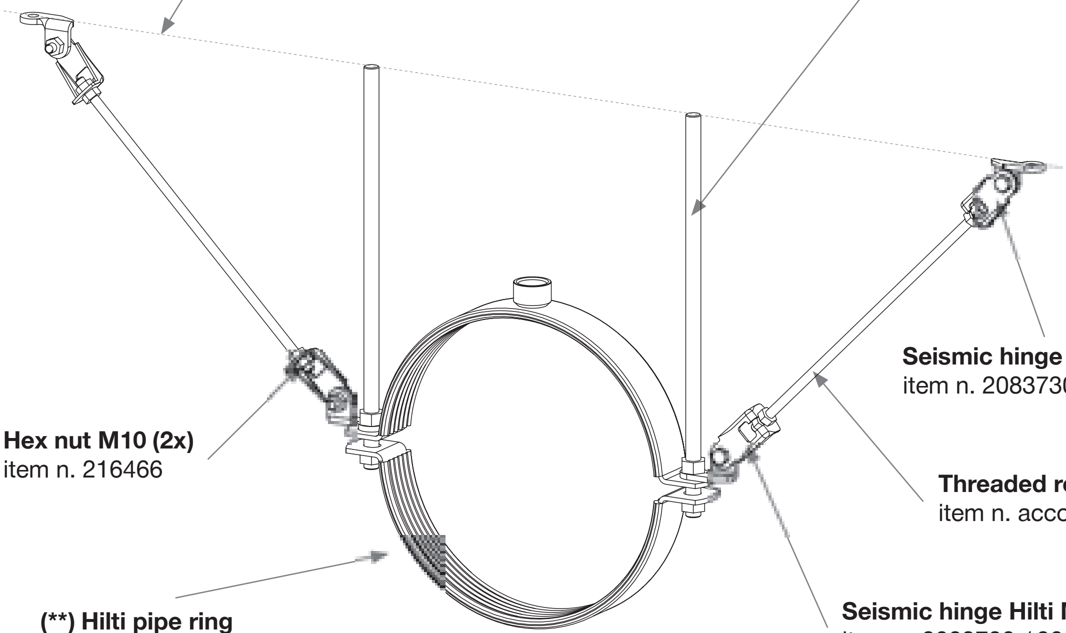
MQS System
Seismic Designed Solutions

Single pipe Transversal bracing	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 0 -	- 2800 -



SEISMIC LOAD ORIENTATION





General Design Notes

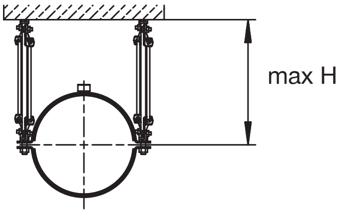
Design loads are stated in this paper are depending on following conditions:

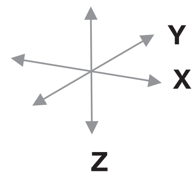
- (*) using M10, M12 or M16 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

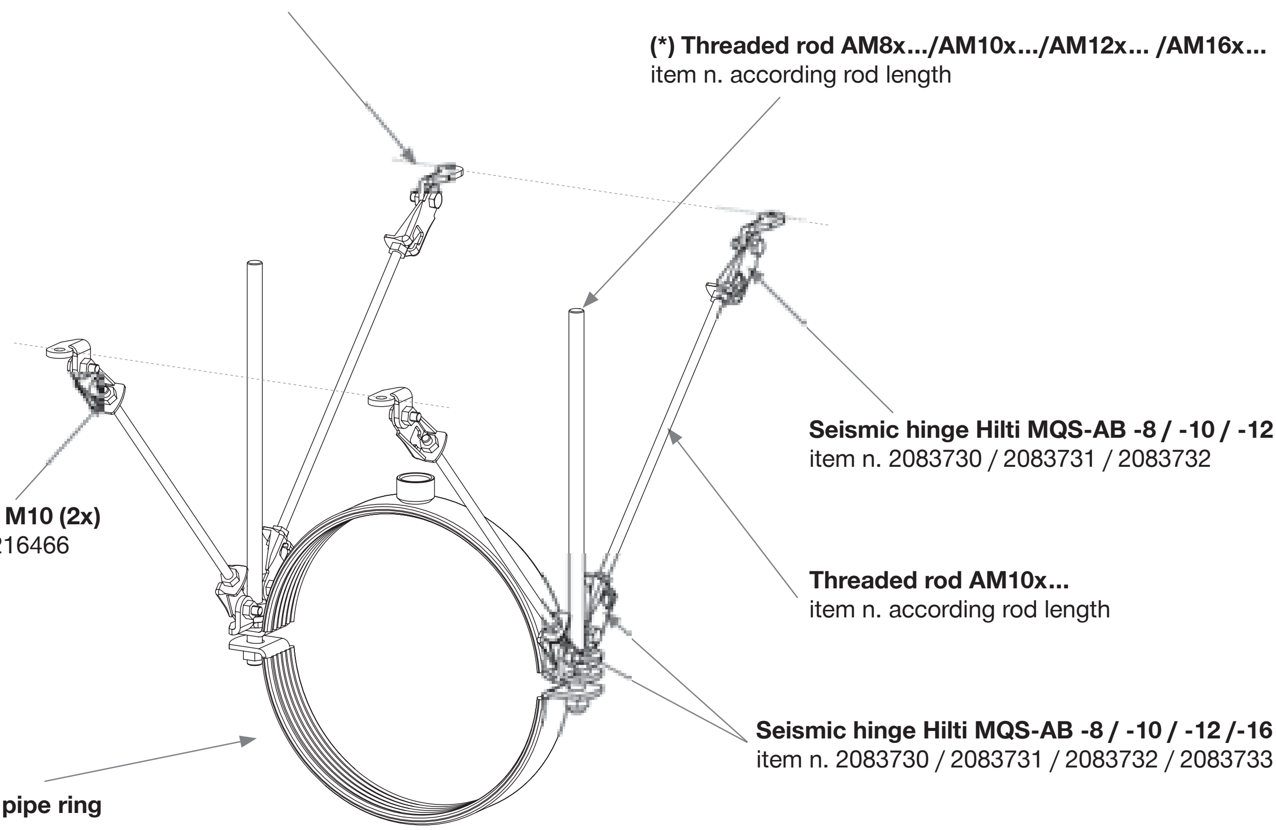
MQS System
Seismic Designed Solutions

Single pipe
Longitudinal bracing

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 2800 -	- 0 -



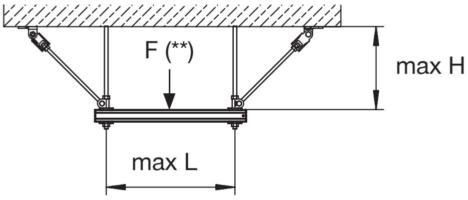




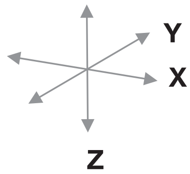
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- (*) using M10, M12 or M16 rods; for applications with M8 vertical rod, please contact the Hilti Technical Service
- (**) for relevant pipe rings – see Annex D
- max. height H – top of ceiling to center of pipe: 800 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C

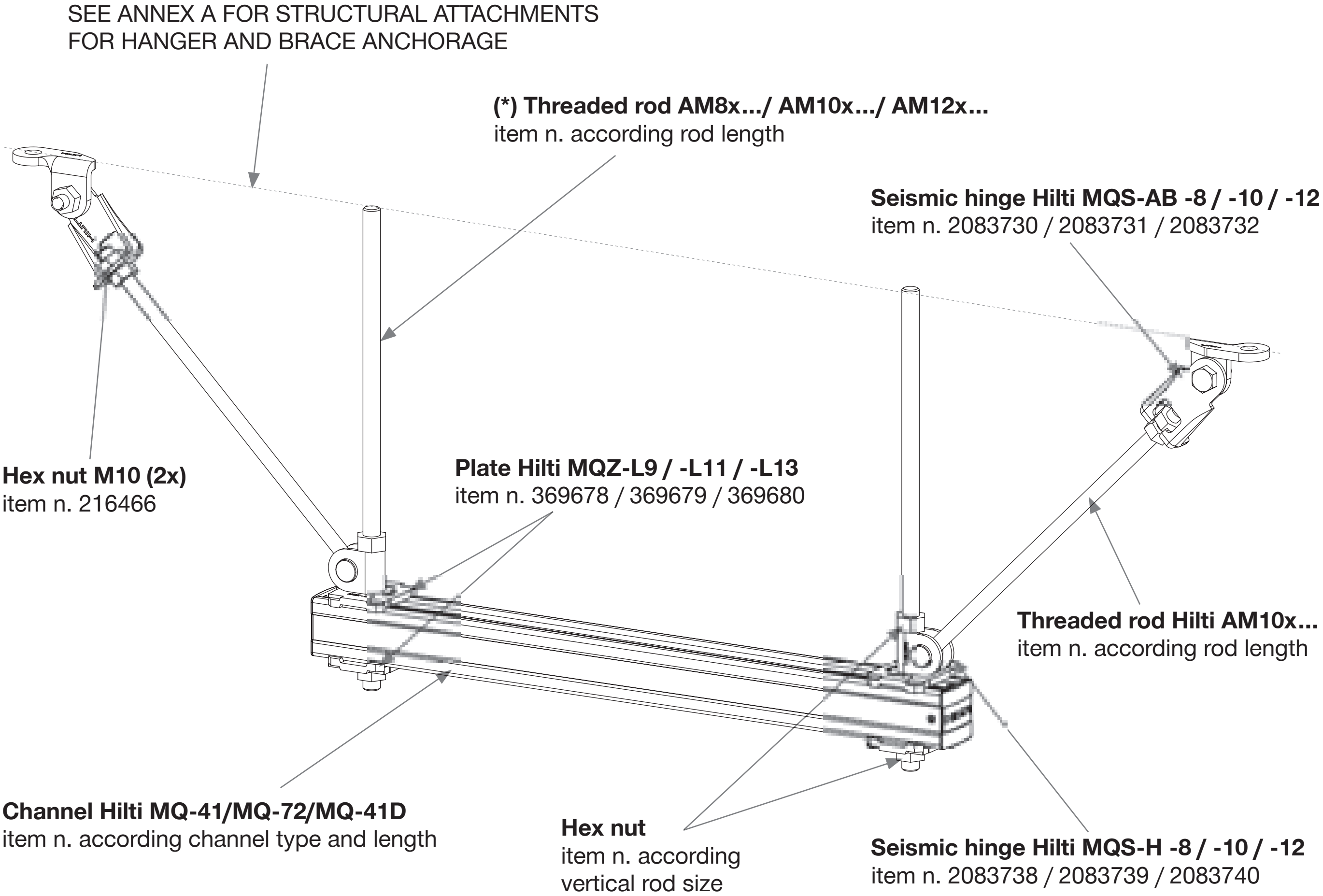
MQS System
Seismic Designed Solutions

Trapeze with rod bracing Transversal	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 0 -	- 2500 -



SEISMIC LOAD ORIENTATION





General Design Notes

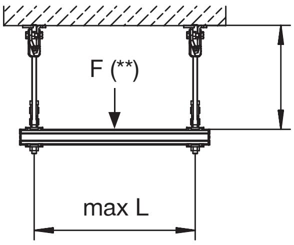
Design loads are stated in this paper are depending on following conditions:

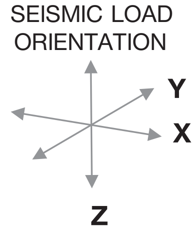
- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

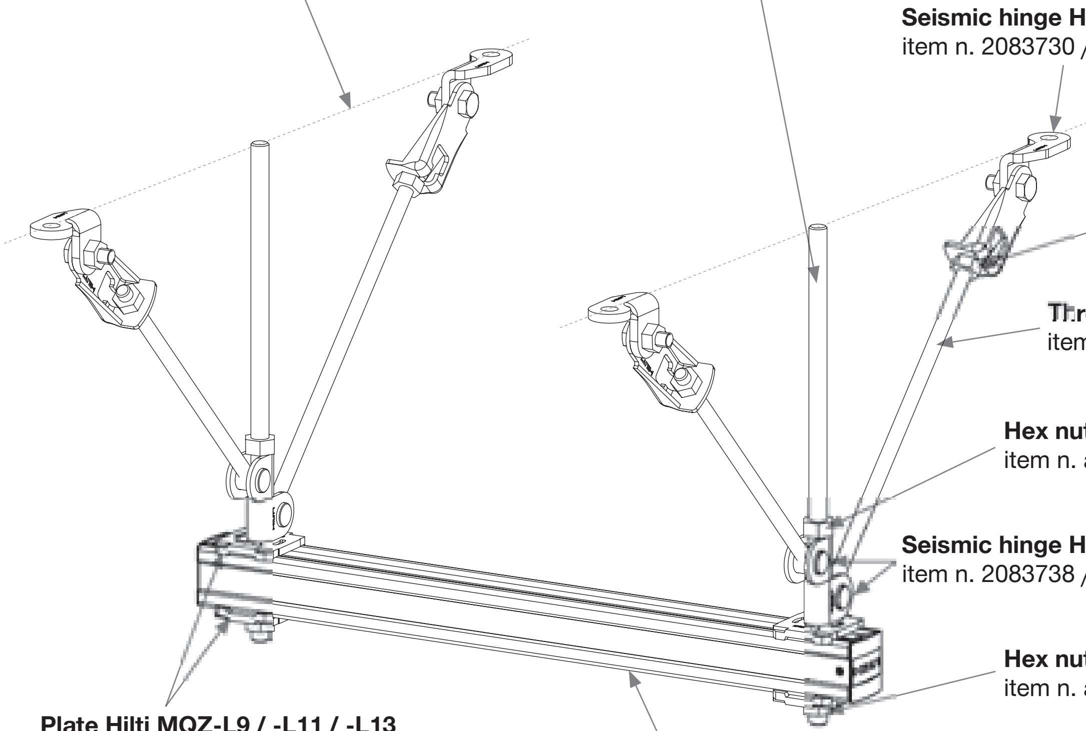
MQS System
Seismic Designed Solutions

Trapeze with rod bracing Longitudinal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 2800 -	- 0 -







General Design Notes

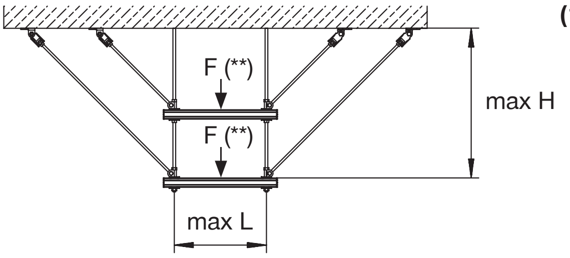
Design loads are stated in this paper are depending on following conditions:

- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

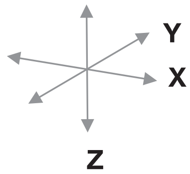
Trapeze with rod bracing Transversal – Multilevel

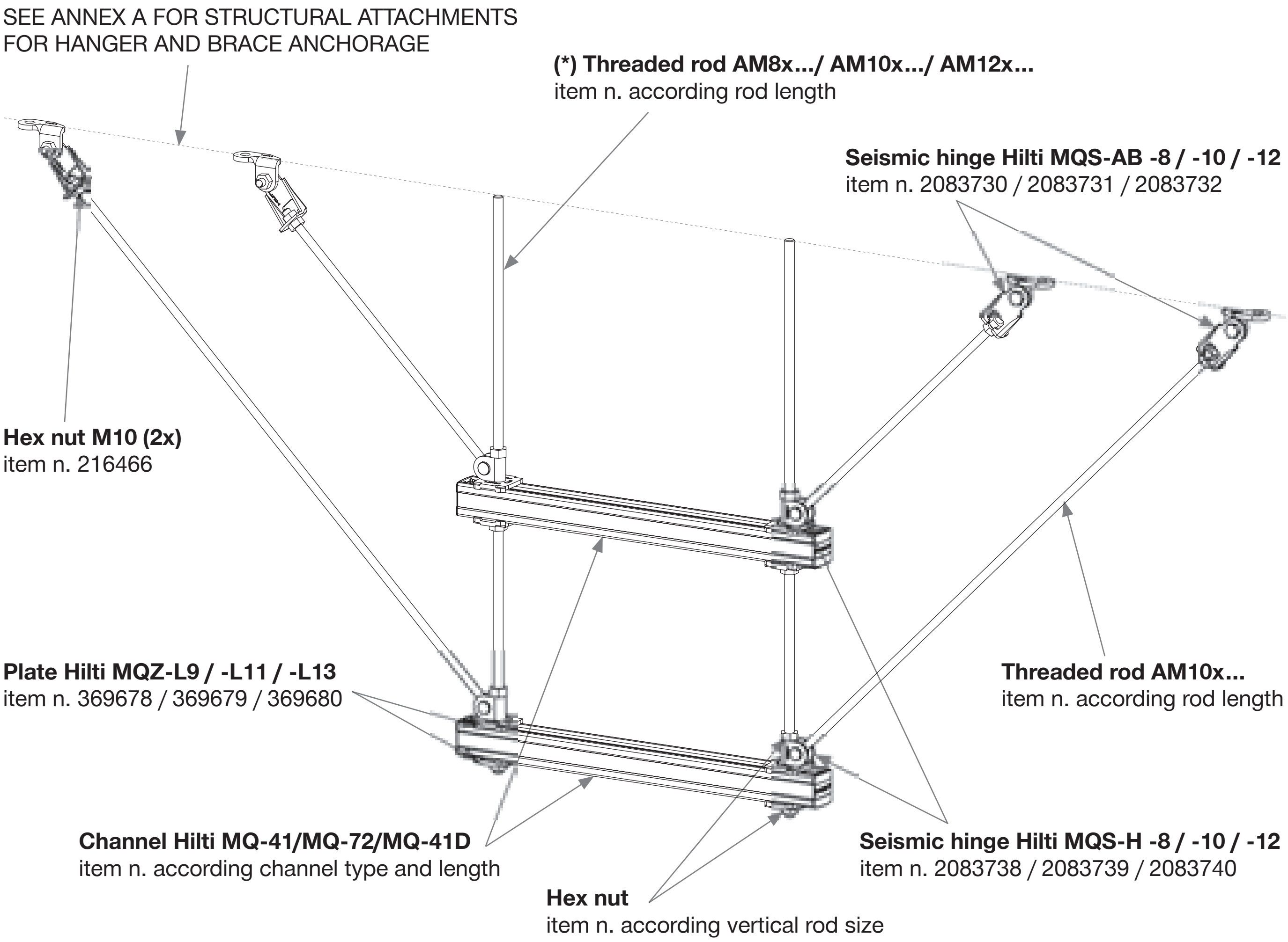
Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 0 -	- 2500 - **(1)**



(1) max desing load for each channel level

SEISMIC LOAD ORIENTATION





General Design Notes

Design loads are stated in this paper are depending on following conditions:

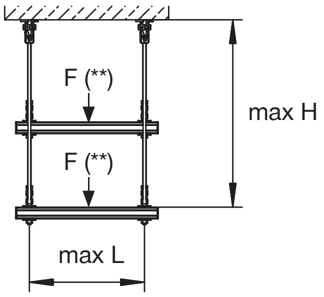
- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B "Selection Tables" or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System

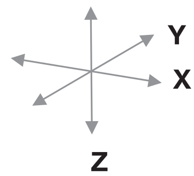
Seismic Designed Solutions

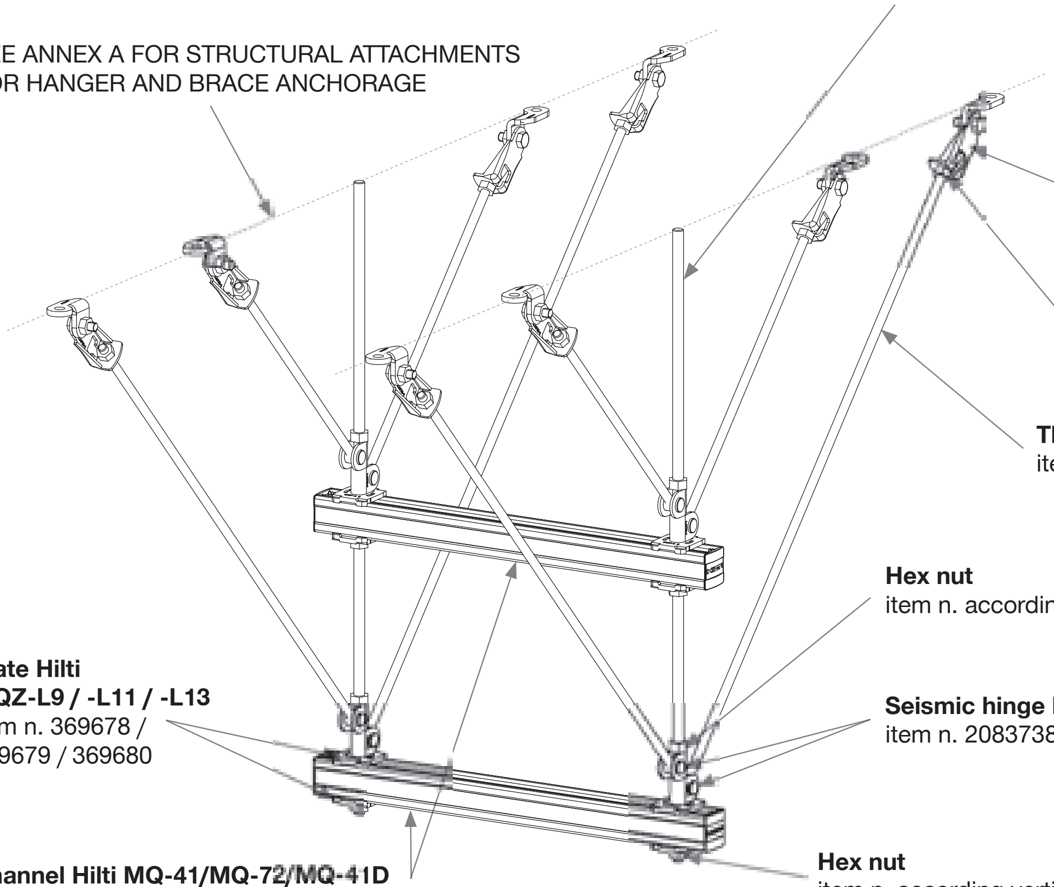
Trapeze with rod bracing Longitudinal – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 2800 - **(1)**	- 0 -



(1) max design load for each channel level





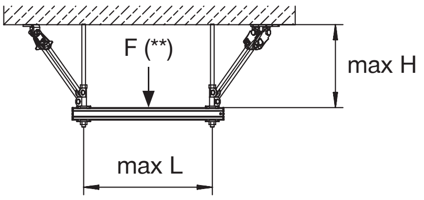
General Design Notes

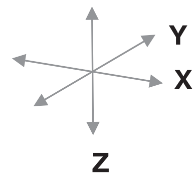
Design loads are stated in this paper are depending on following conditions:

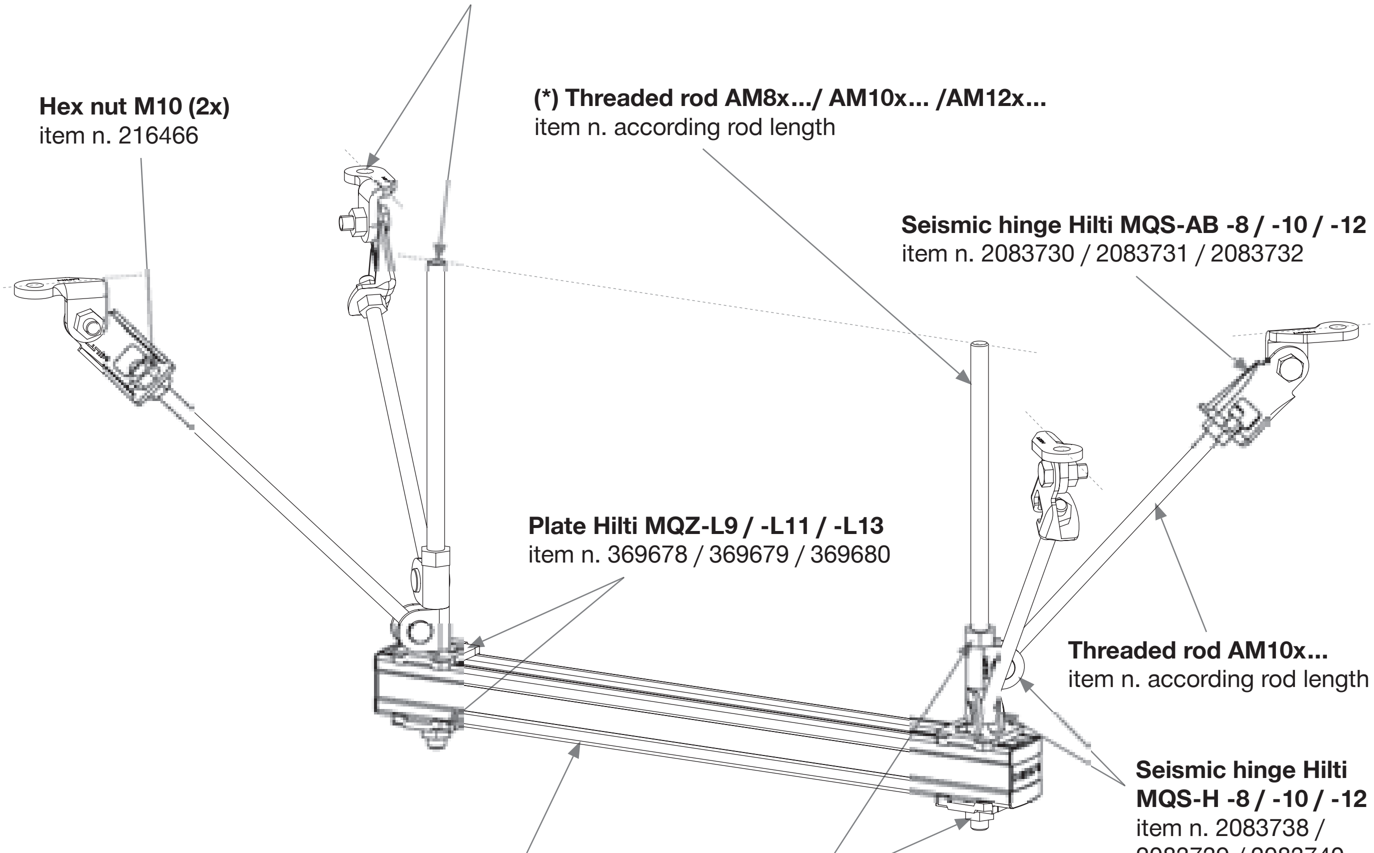
- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

# Trapeze with rod bracing 4-way bracing	**Max. design load (seismic horizontal) in [N]**	
	Longitudinal [Y]	**Transversal [X]**
	Calculation with PROFIS is needed	







General Design Notes

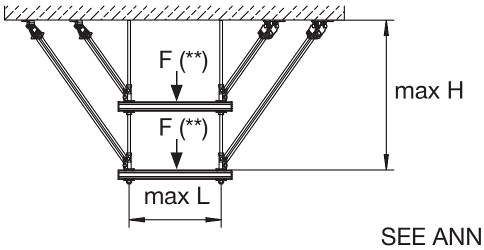
Design loads are stated in this paper are depending on following conditions:

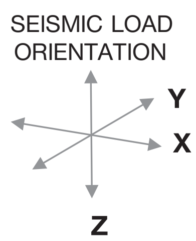
- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

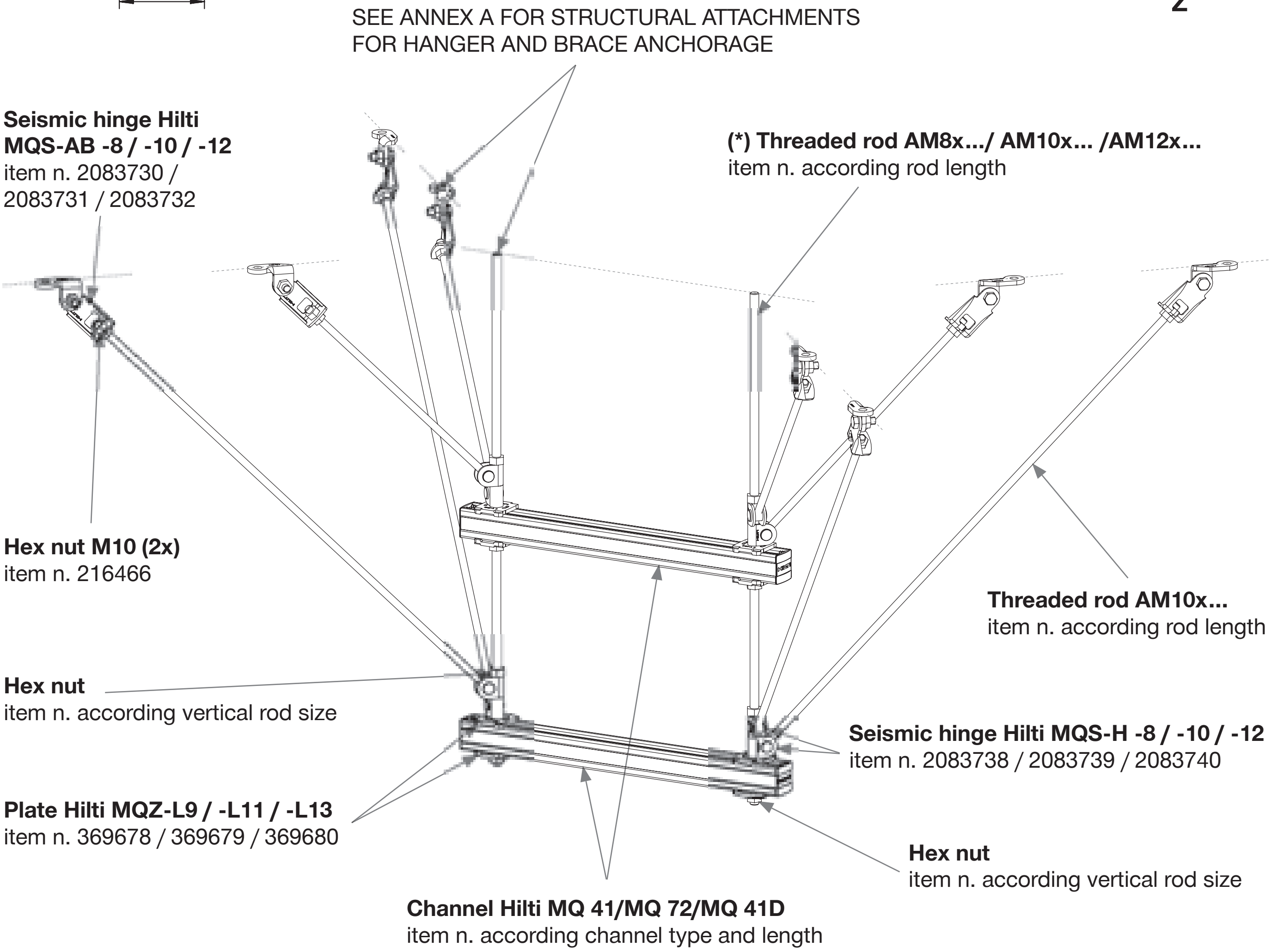
MQS System
Seismic Designed Solutions

Trapeze with rod bracing 4-way bracing – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
Calculation with PROFIS is needed	







General Design Notes

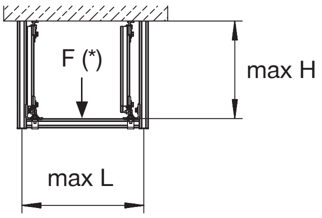
Design loads are stated in this paper are depending on following conditions:

- (*) using M10 or M12 rods; for applications with M8 vertical rods, please contact the Hilti Technical Service
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B "Selection Tables" or use PROFIS Installation
- F(**): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

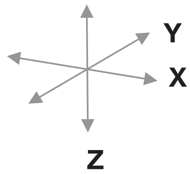
MQS System
Seismic Designed Solutions

Trapeze with channel bracing Longitudinal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
See Annex E - Selection Tables	

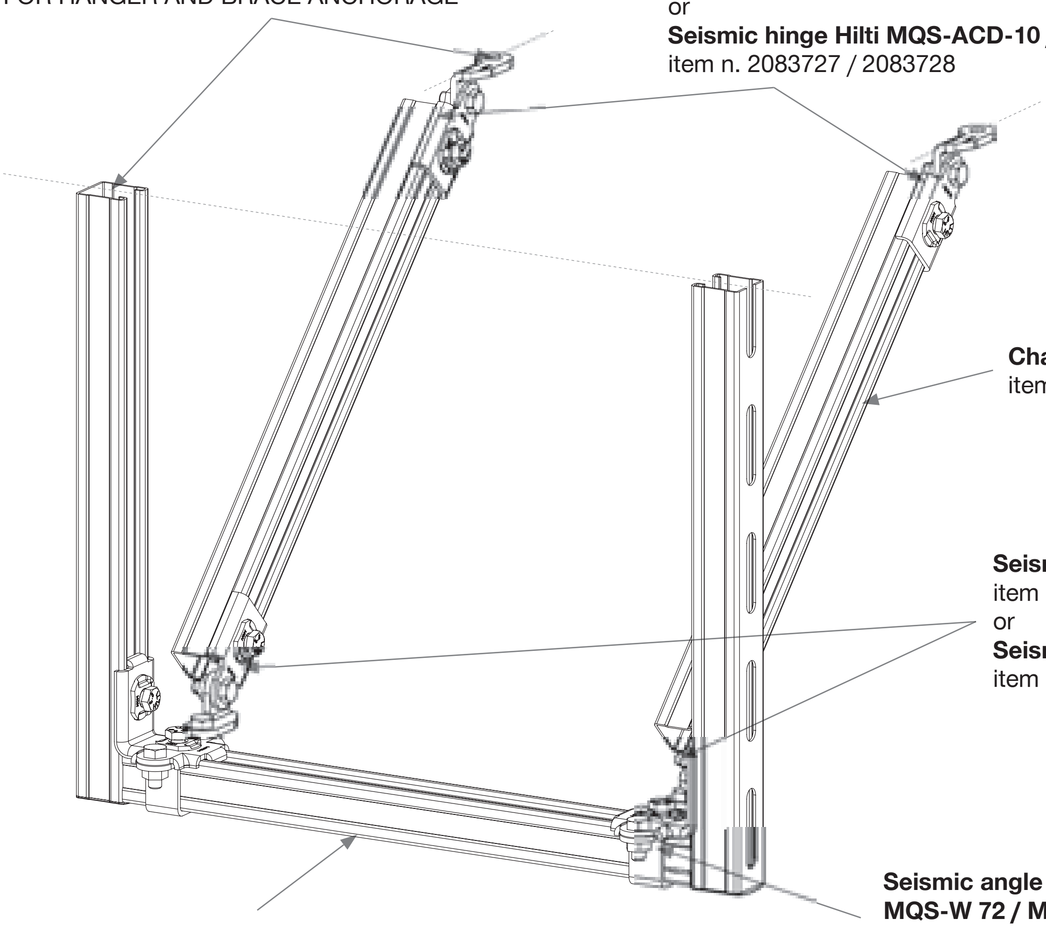


SEISMIC LOAD ORIENTATION



SEE ANNEX A FOR STRUCTURAL ATTACHMENTS FOR HANGER AND BRACE ANCHORAGE

Seismic hinge Hilti MQS-AC-10 / MQS-AC-12
item n. 2083725 / 2083726
or
Seismic hinge Hilti MQS-ACD-10 / MQS-ACD-12
item n. 2083727 / 2083728



Channel Hilti MQ-41
item n. according channel length

Seismic hinge Hilti MQS-AC-10
item n. 2083725
or
Seismic hinge Hilti MQS-ACD-10
item n. 2083727

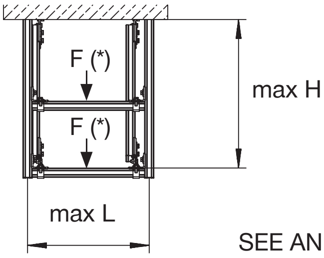
Seismic angle Hilti MQS-W 41 / MQS-W 72 / MQS-W 41D set
item n. 2083735 / 2083736 / 2083737

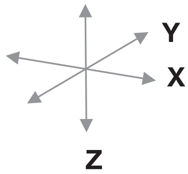
Channel Hilti MQ-41/MQ-72/MQ-41D
item n. according channel type and length

General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

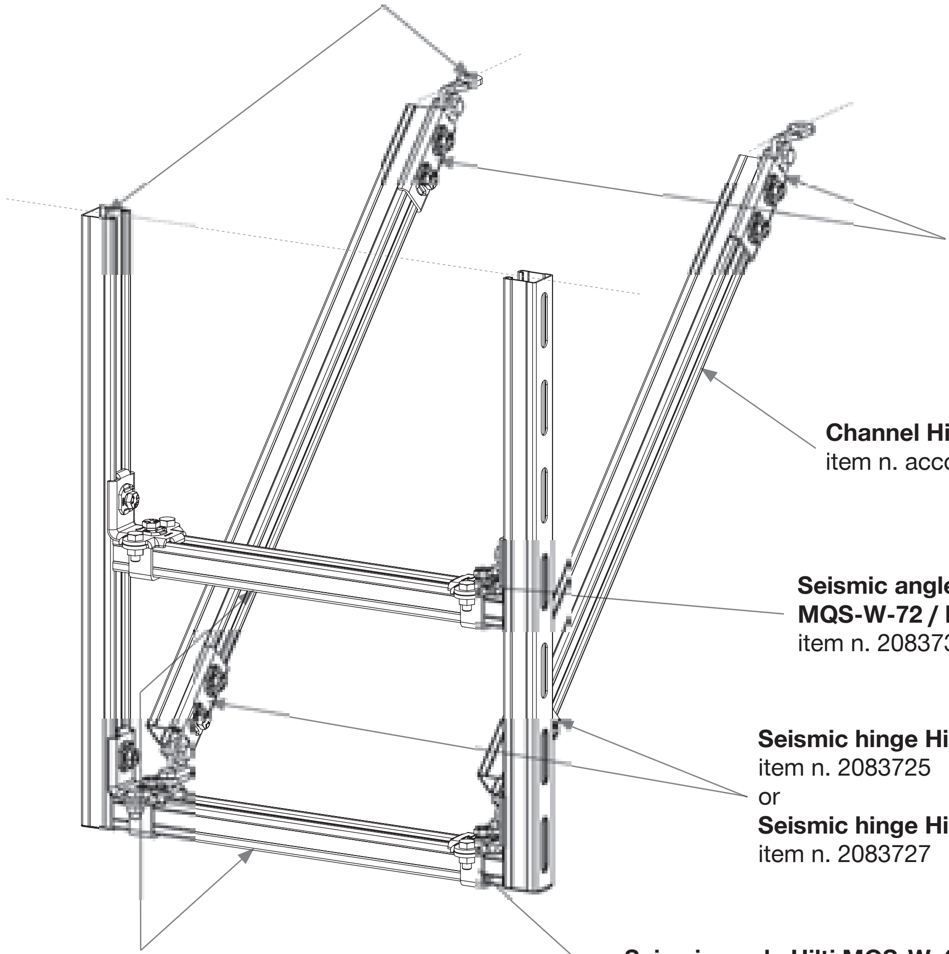
MQS System
Seismic Designed Solutions

Trapeze with channel bracing Longitudinal – Multilevel	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	Calculation with PROFIS is needed	





SEE ANNEX A FOR STRUCTURAL ATTACHMENTS FOR HANGER AND BRACE ANCHORAGE



Seismic hinge Hilti MQS-AC-10 / MQS-AC-12
item n. 2083725 / 2083726
or
Seismic hinge Hilti MQS-ACD-10 / MQS-ACD-12
item n. 2083727 / 2083728

Channel Hilti MQ-41
item n. according channel length

Seismic angle Hilti MQS-W-41 / MQS-W-72 / MQS-W-41D set
item n. 2083735 / 2083736 / 2083737

Seismic hinge Hilti MQS-AC-10
item n. 2083725
or
Seismic hinge Hilti MQS-ACD-10
item n. 2083727

Channel Hilti MQ 41/MQ 72/MQ 41D
item n. according channel type and length

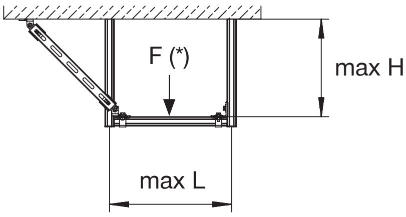
Seismic angle Hilti MQS-W-41 / MQS-W-72 / MQS-W-41D set
item n. 2083735 / 2083736 / 2083737

General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

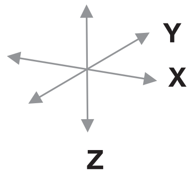
MQS System
Seismic Designed Solutions

Trapeze with channel bracing
Transversal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
See Annex E - Selection Tables	

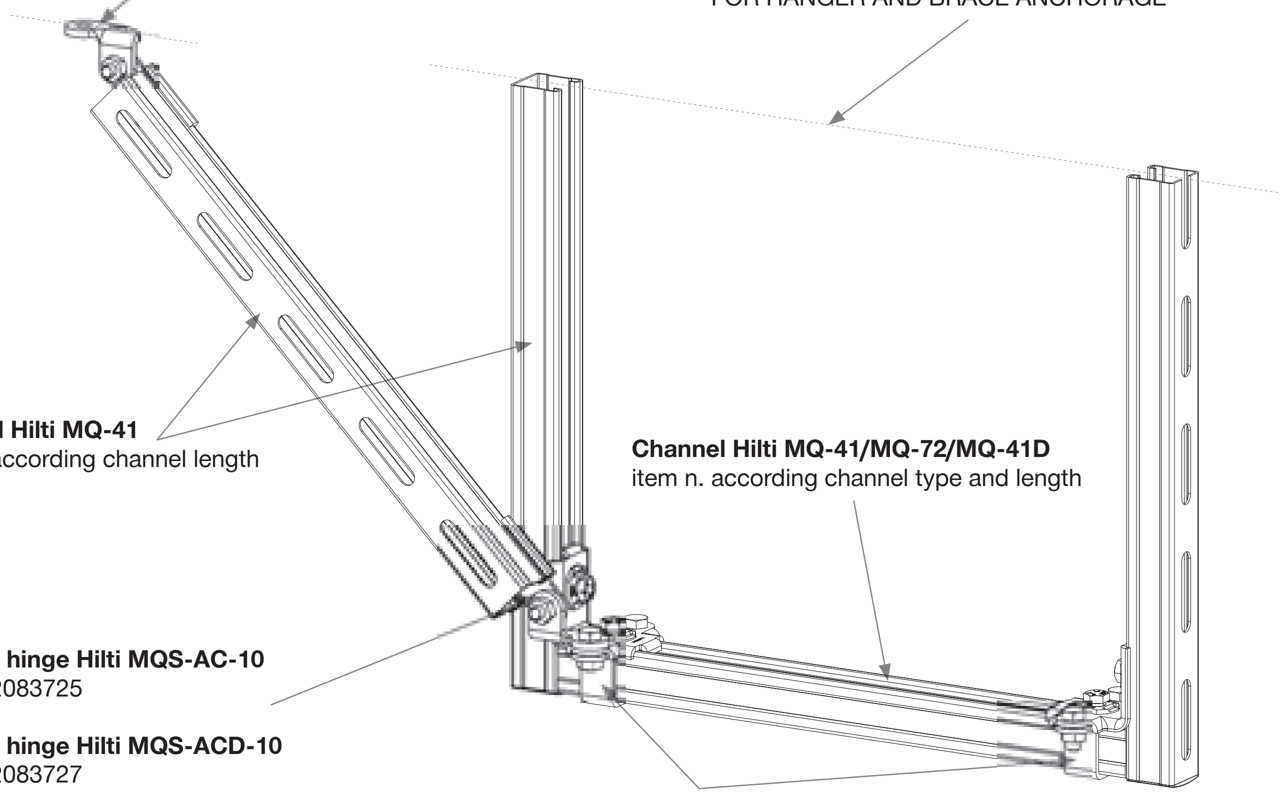


SEISMIC LOAD ORIENTATION



Seismic hinge Hilti MQS-AC-10 / MQS-AC-12
item n. 2083725 / 2083726
or
Seismic hinge Hilti MQS-ACD-10 / MQS-ACD-12
item n. 2083727 / 2083728

SEE ANNEX A FOR STRUCTURAL ATTACHMENTS FOR HANGER AND BRACE ANCHORAGE



Channel Hilti MQ-41
item n. according channel length

Channel Hilti MQ-41/MQ-72/MQ-41D
item n. according channel type and length

Seismic hinge Hilti MQS-AC-10
item n. 2083725
or
Seismic hinge Hilti MQS-ACD-10
item n. 2083727

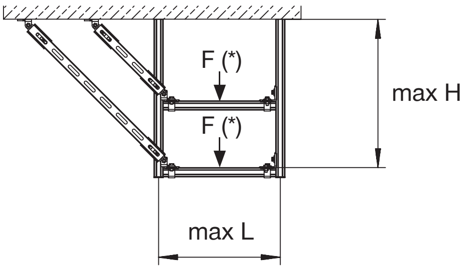
Seismic angle Hilti MQS-W-41 / MQS-W-72 / MQS-W-41D set
item n. 2083735 / 2083736 / 2083737

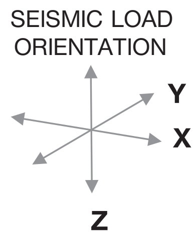
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

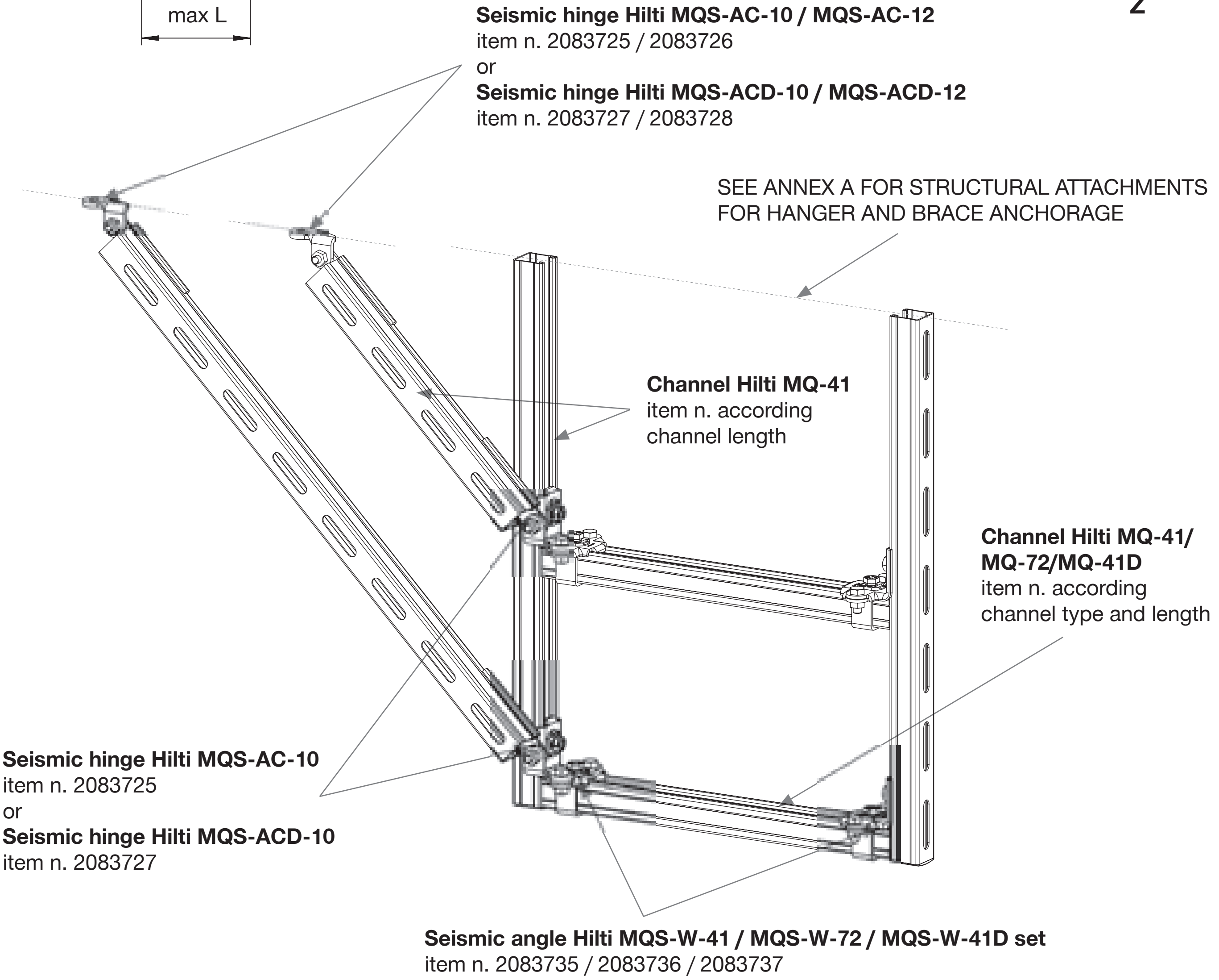
MQS System
Seismic Designed Solutions

Trapeze with channel bracing Transversal – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
Calculation with PROFIS is needed	





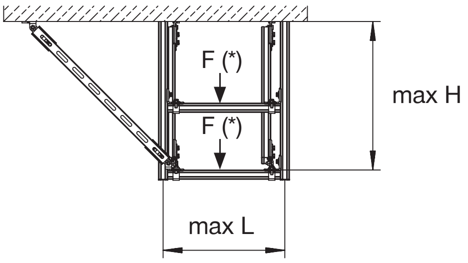


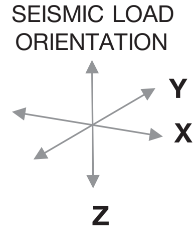
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

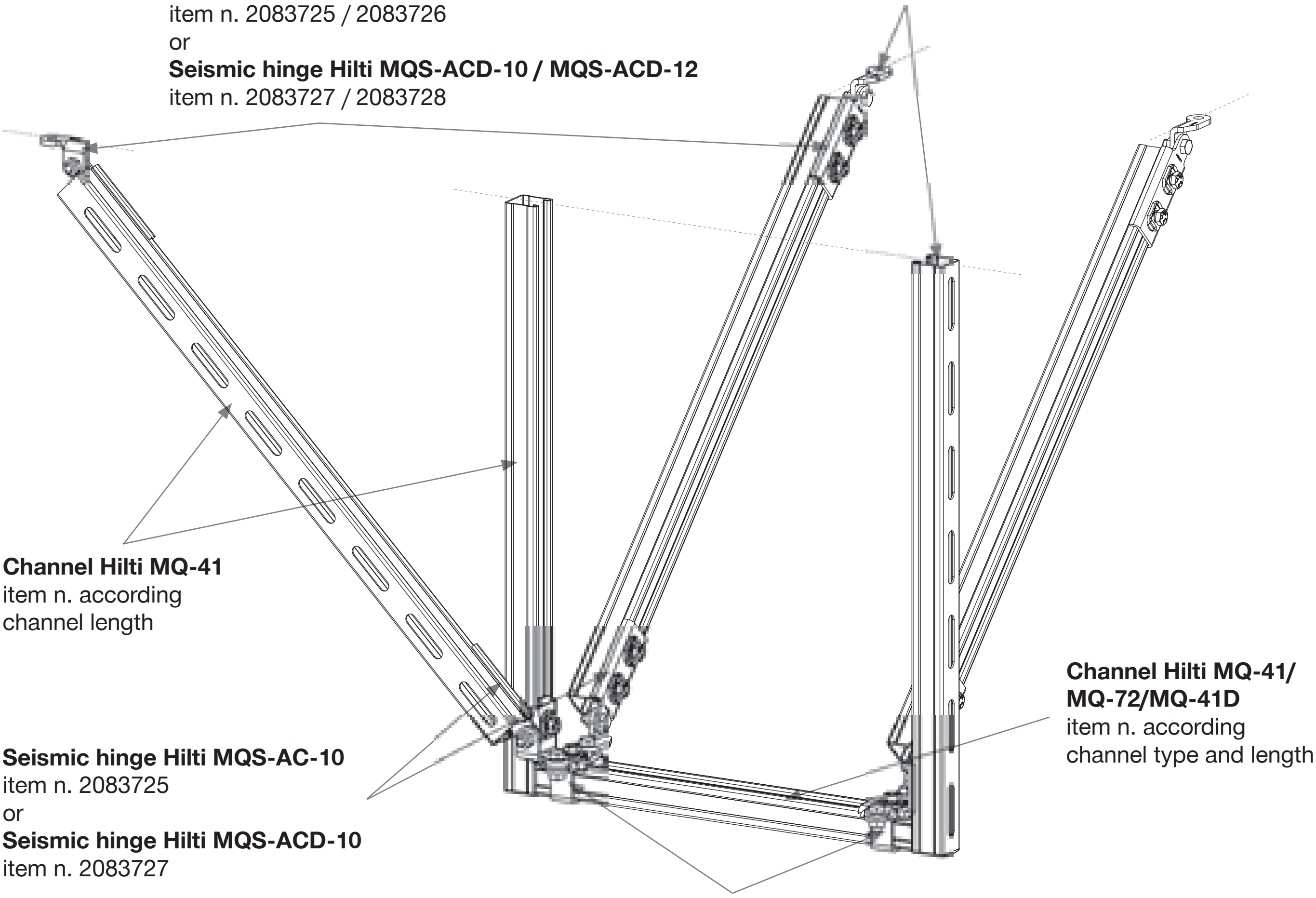
MQS System
Seismic Designed Solutions

Trapeze with channel bracing 4-way bracing

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
See Annex E - Selection Tables	







General Design Notes

Design loads are stated in this paper are depending on following conditions:

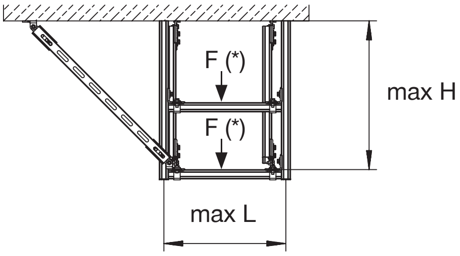
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System

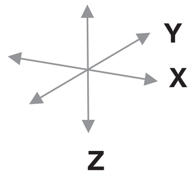
Seismic Designed Solutions

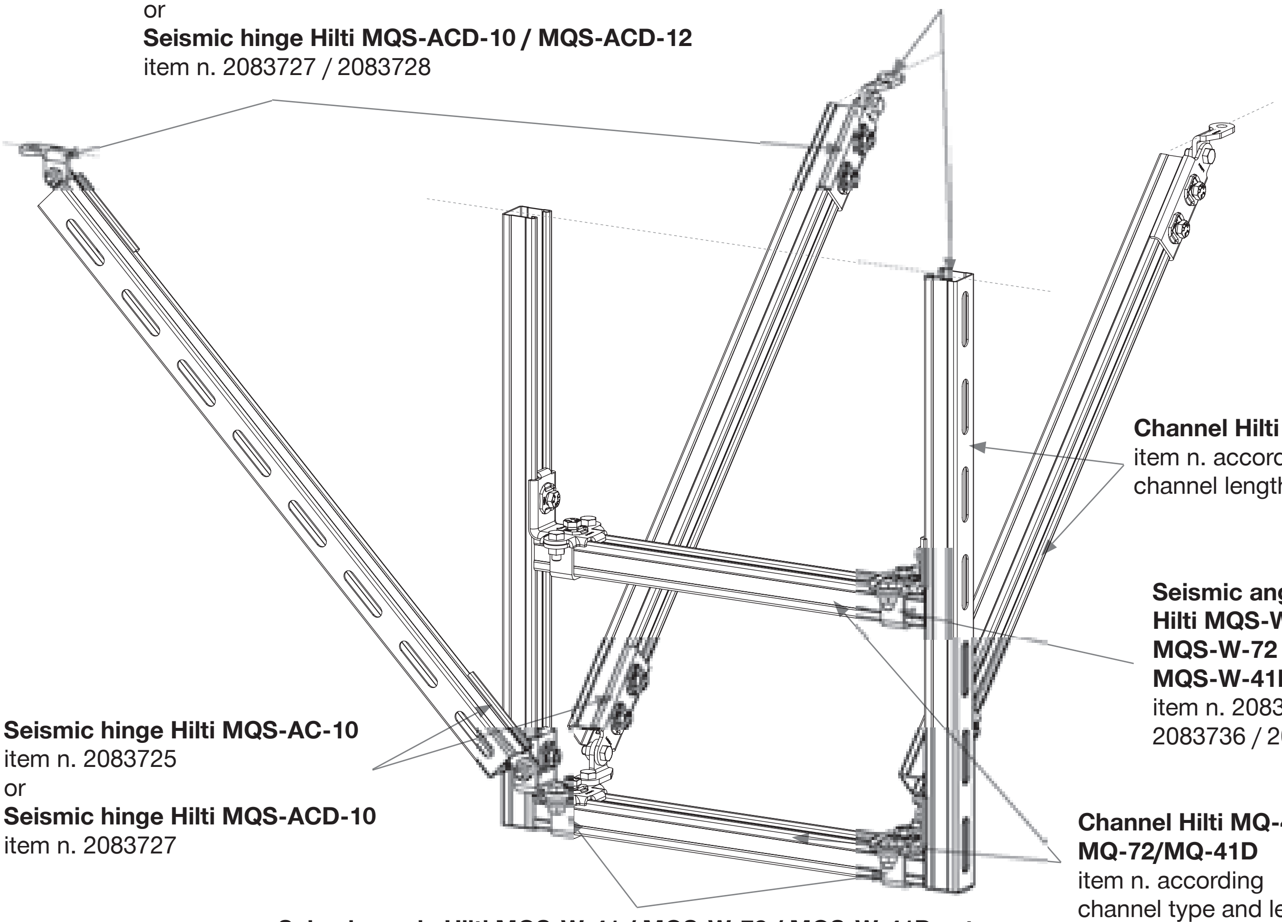
Trapeze with channel bracing 4-way bracing – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	**Transversal [X]**
Calculation with PROFIS is needed	



SEISMIC LOAD ORIENTATION



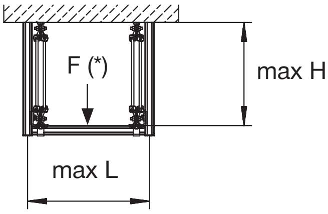


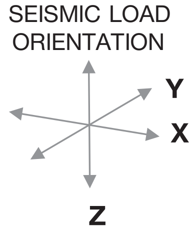
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

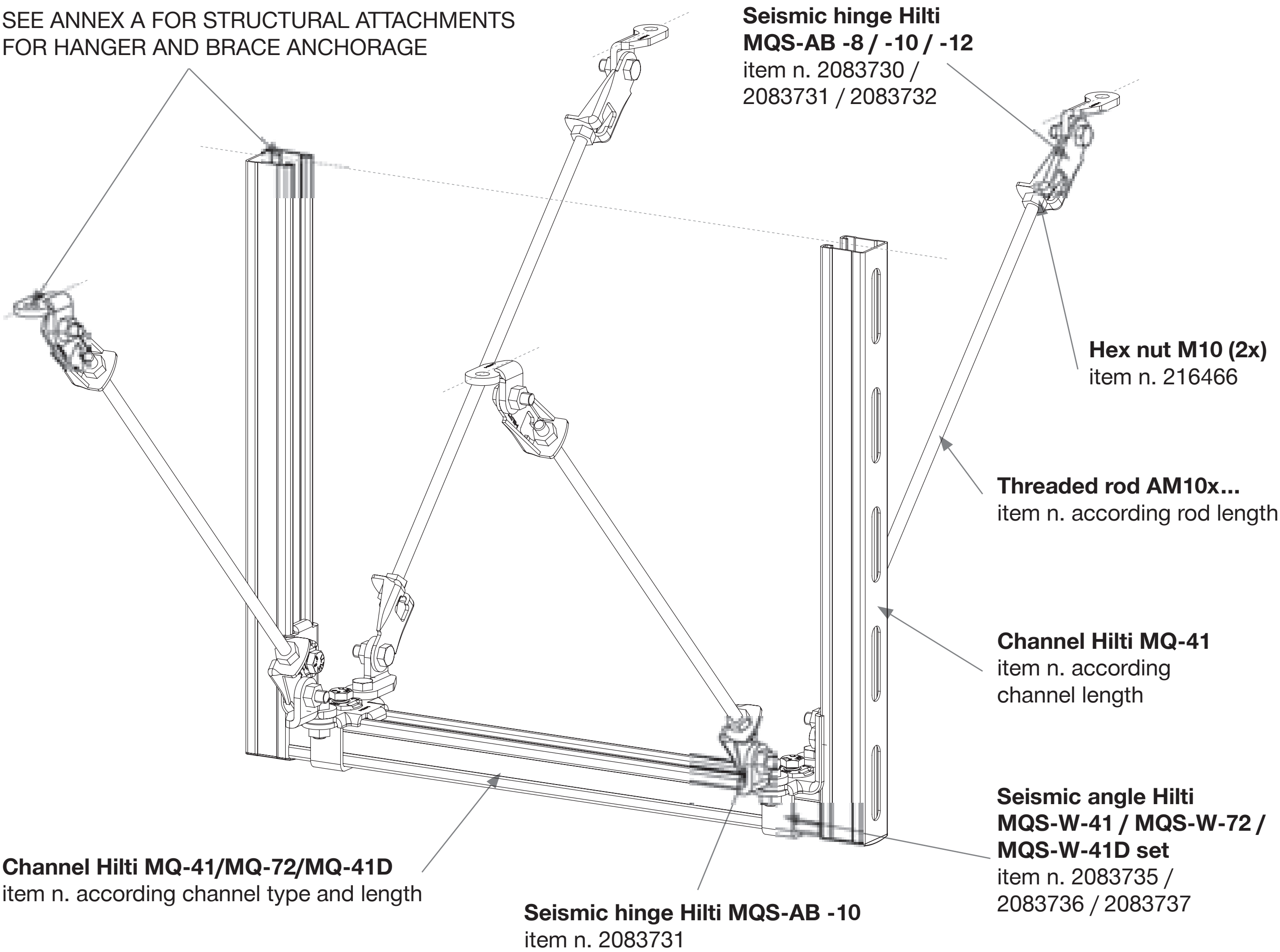
MQS System
Seismic Designed Solutions

Trapeze with rod bracing Longitudinal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 2800 -	- 0 -







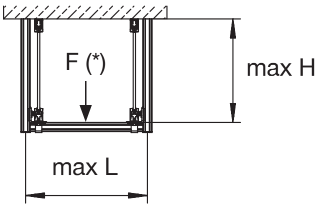
General Design Notes

Design loads are stated in this paper are depending on following conditions:

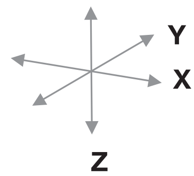
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

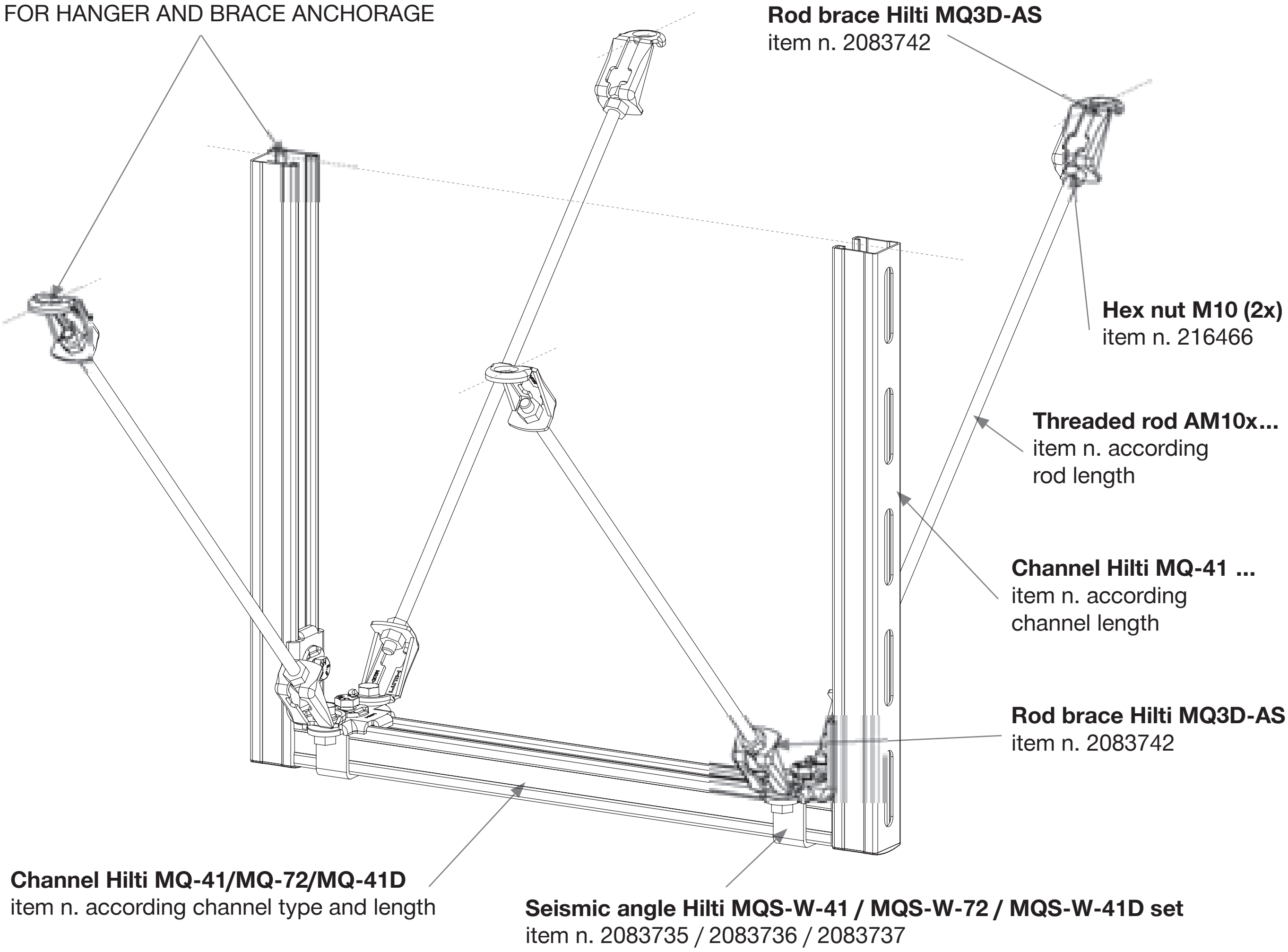
Trapeze with rod bracing Longitudinal	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	- 2800 -	- 0 -



SEISMIC LOAD ORIENTATION



SEE ANNEX A FOR STRUCTURAL ATTACHMENTS FOR HANGER AND BRACE ANCHORAGE



General Design Notes

Design loads are stated in this paper are depending on following conditions:

- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

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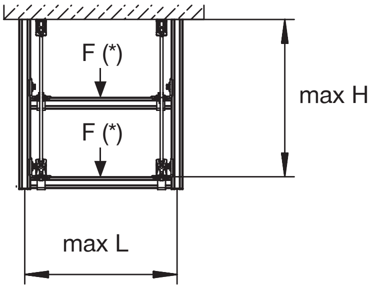
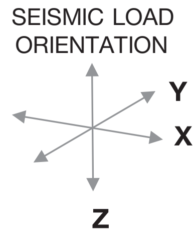
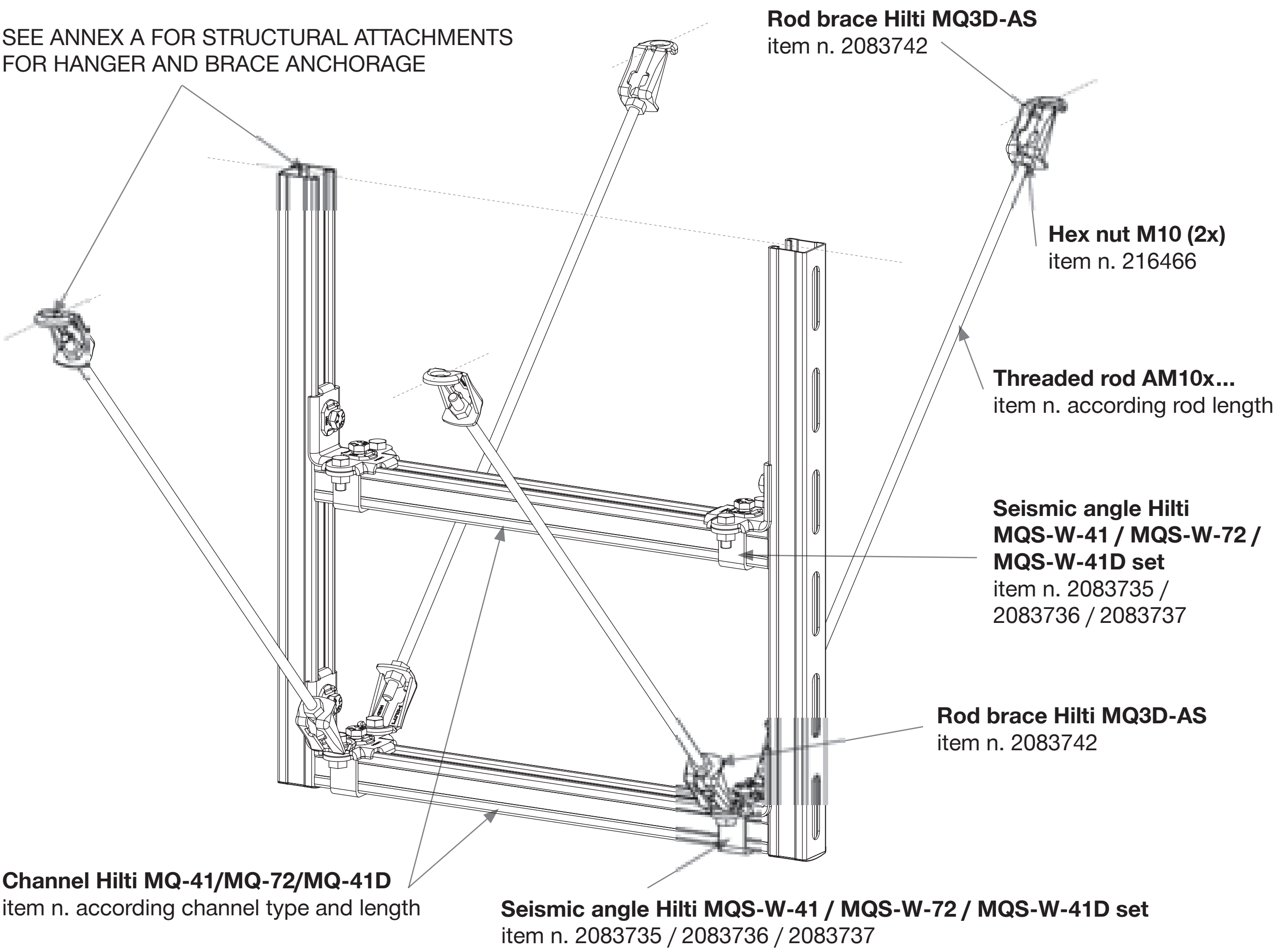
Trapeze with rod bracing Longitudinal – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
Calculation with PROFIS is needed	







General Design Notes

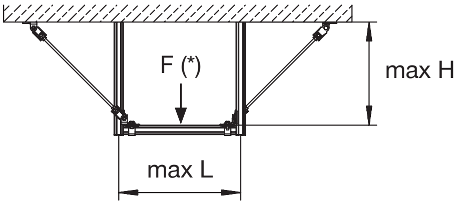
Design loads are stated in this paper are depending on following conditions:

- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

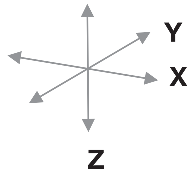
MQS System
Seismic Designed Solutions

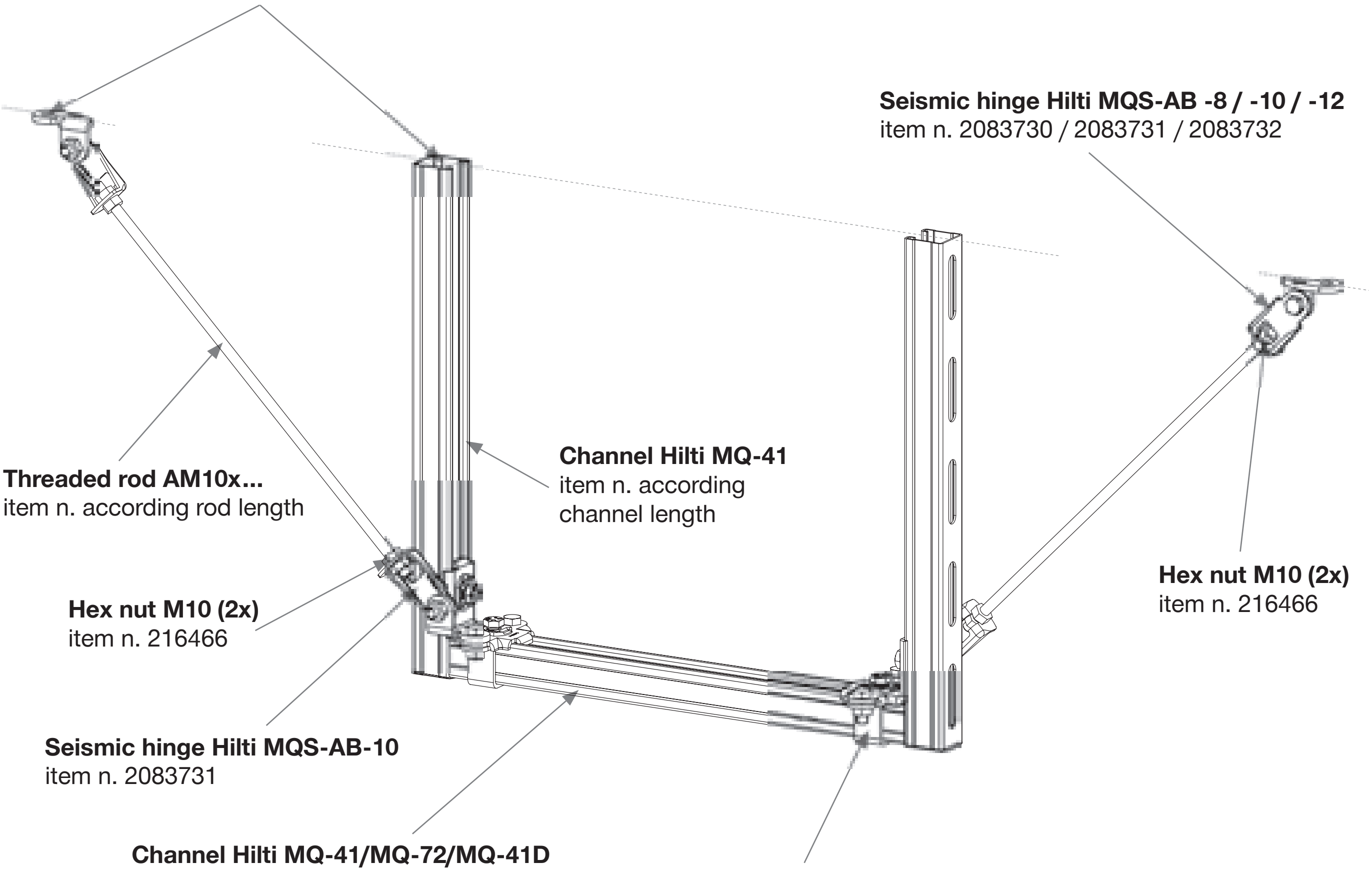
Trapeze with rod bracing Transversal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 0 -	- 2800 -



SEISMIC LOAD ORIENTATION



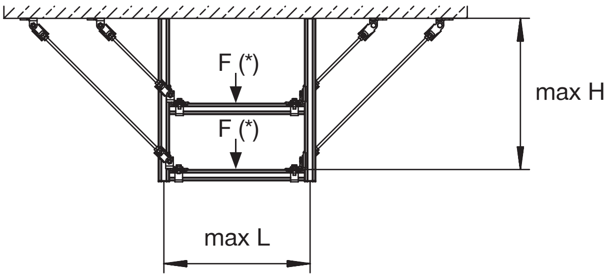


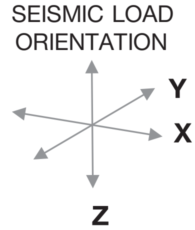
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

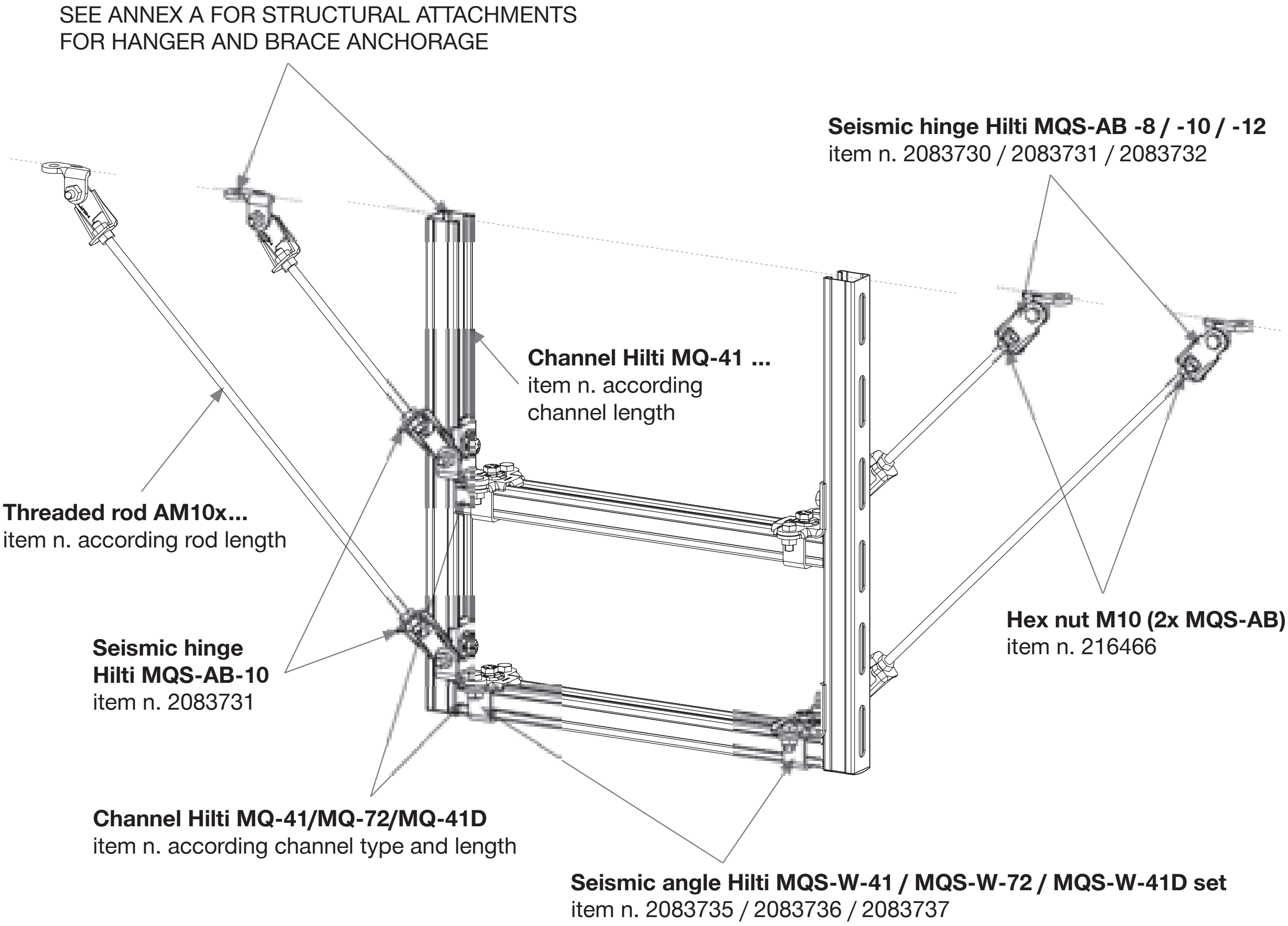
MQS System
Seismic Designed Solutions

Trapeze with rod bracing Transversal – Multilevel

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
Calculation with PROFIS is needed	



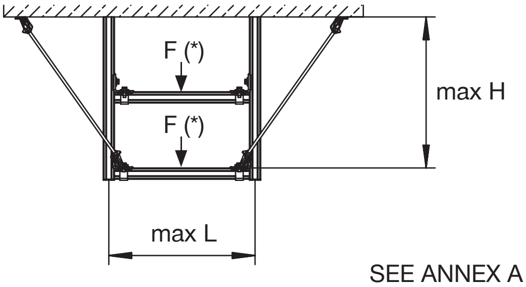


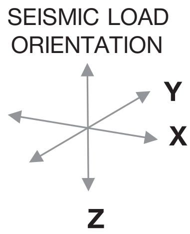


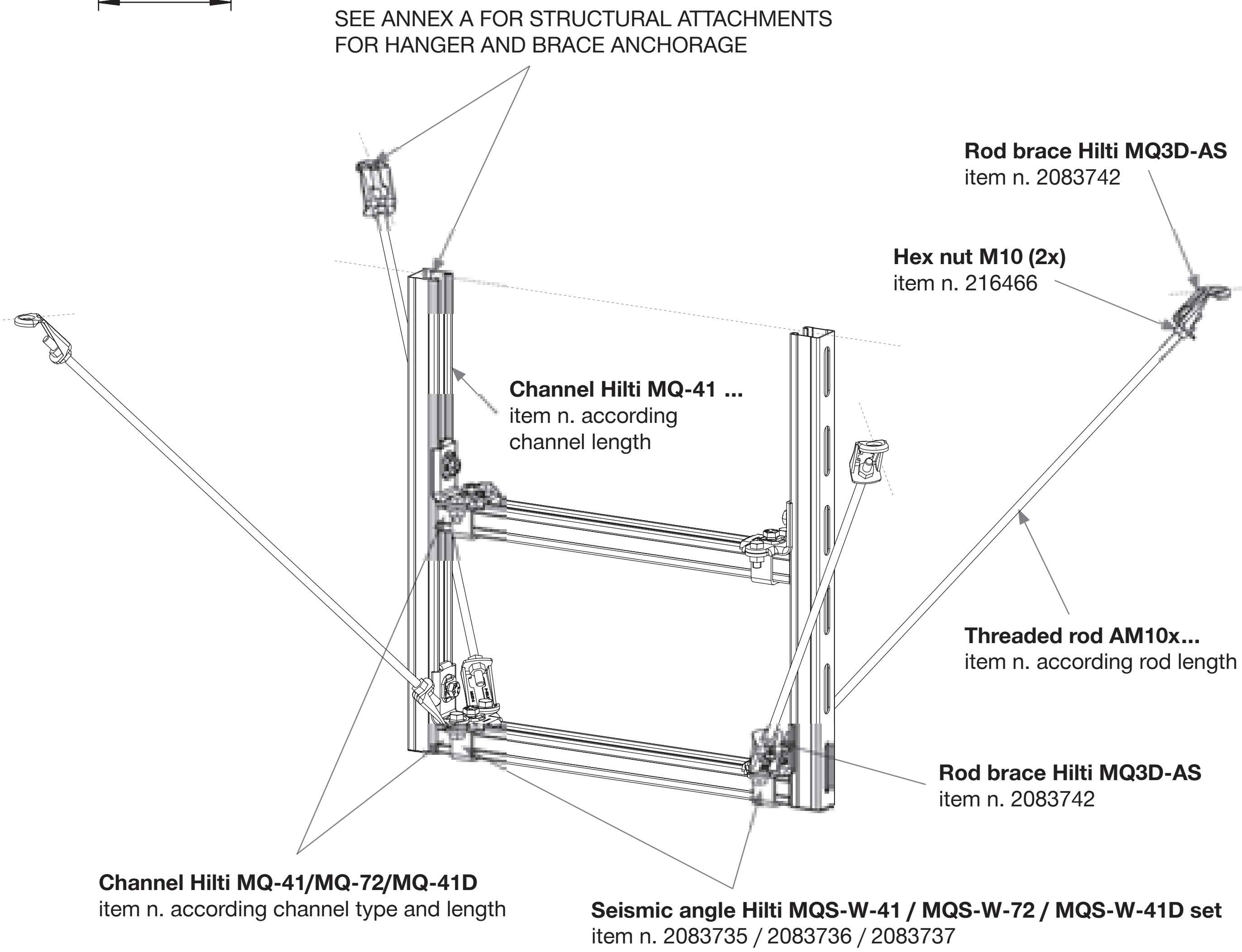
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

# Trapeze with rod bracing 4-way bracing – Multilevel	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	**Transversal [X]**
	Calculation with PROFIS is needed	







General Design Notes

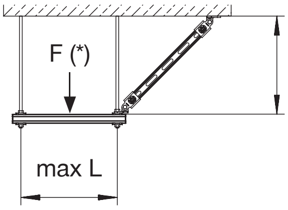
Design loads are stated in this paper are depending on following conditions:

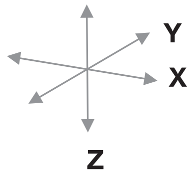
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

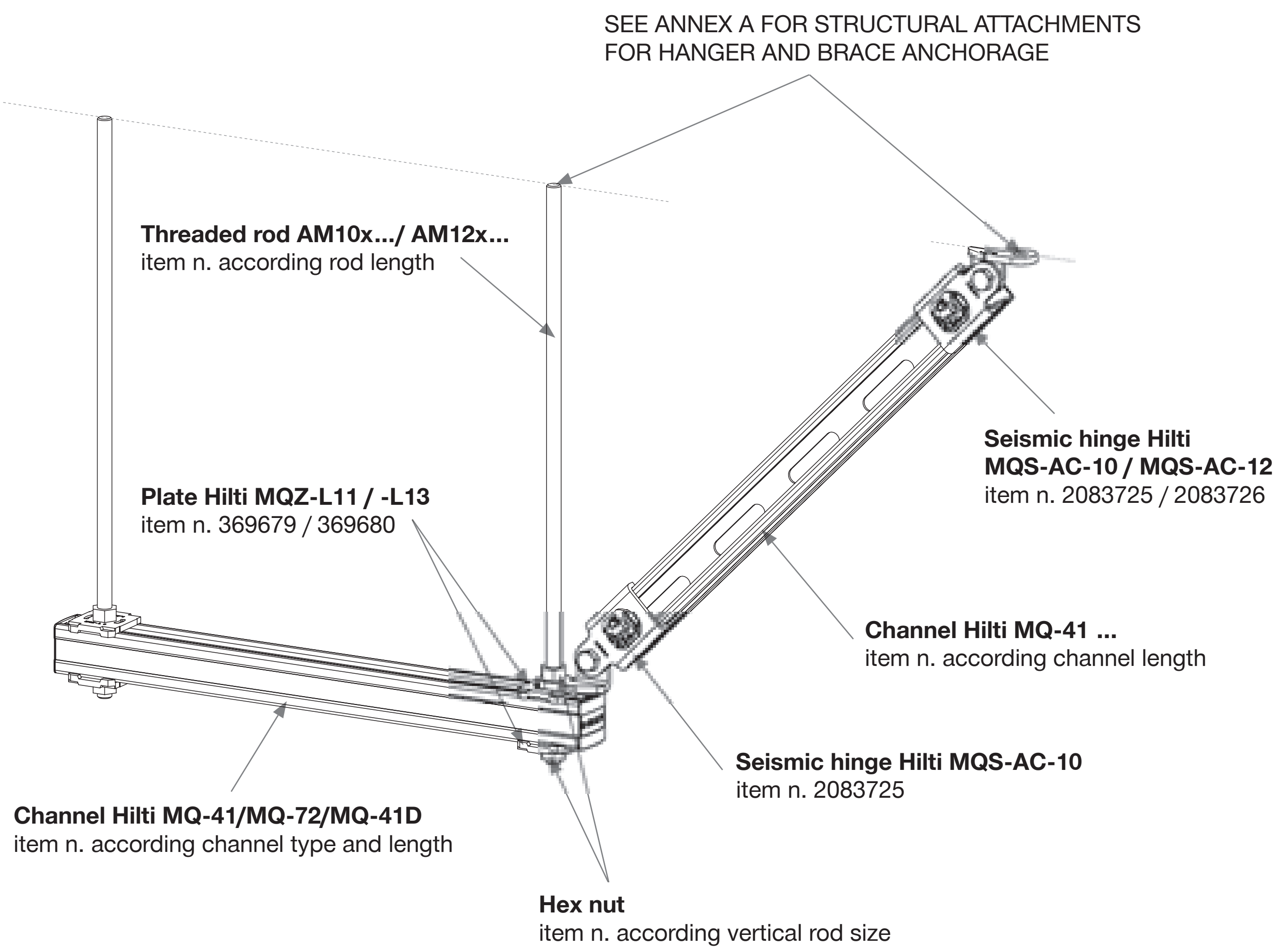
MQS System
Seismic Designed Solutions

Trapeze with channel bracing Transversal

Max. design load (seismic horizontal) in [N]	
Longitudinal [Y]	Transversal [X]
- 0 -	- 2500 -



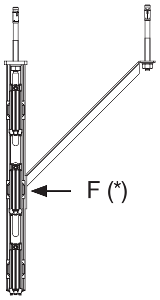


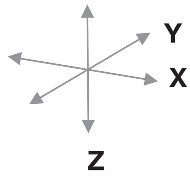


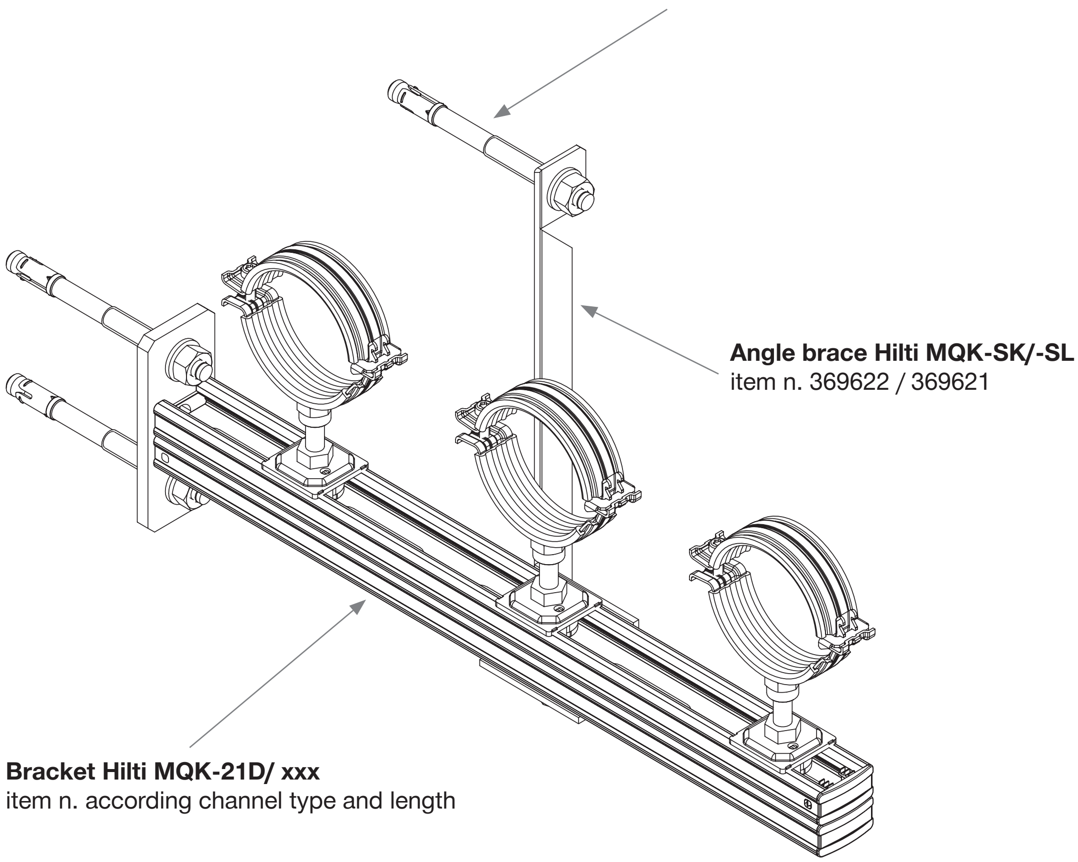
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- max. height H – top of ceiling to top of horizontal channel: 800 mm; max. length L: 1600 mm
- brace angle: 45° – any or all brace locations are permitted to use the full angle variation to meet field conditions – see Annex A
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – see Annex B “Selection Tables” or use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

Wall bracket	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	Calculation with PROFIS is needed	



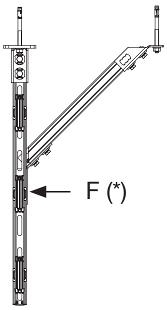


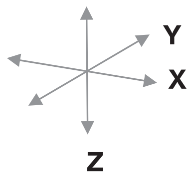


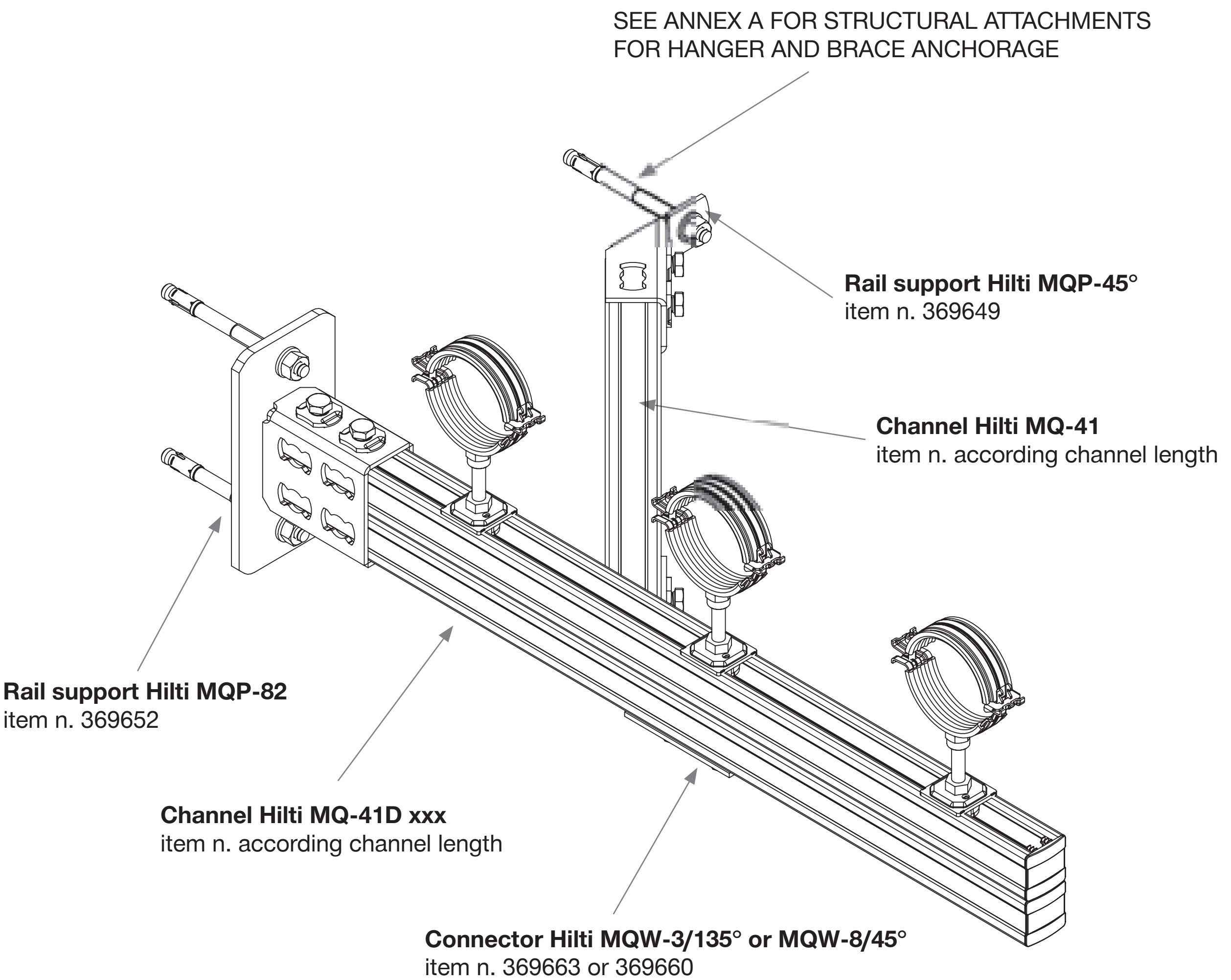
General Design Notes
Design loads are stated in this paper are depending on following conditions:
- structural attachments for hanger and braces – see Annex C
- capacity for particular load situations – use PROFIS Installation
- F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

Wall bracket	Max. design load (seismic horizontal) in [N]	
	Longitudinal [Y]	Transversal [X]
	Calculation with PROFIS is needed	







General Design Notes
Design loads are stated in this paper are depending on following conditions:
• structural attachments for hanger and braces – see Annex C
• capacity for particular load situations – use PROFIS Installation
• F(*): for trade relevant attachments (piping / cable trays / air ducts) – see Annex D

MQS System
Seismic Designed Solutions

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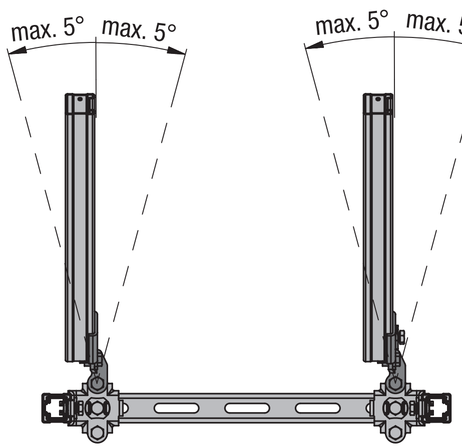
Angle variation of bracing with channels

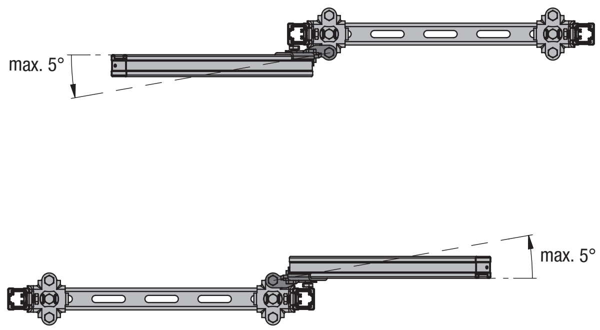
MQS Seismic System

Longitudinal bracing



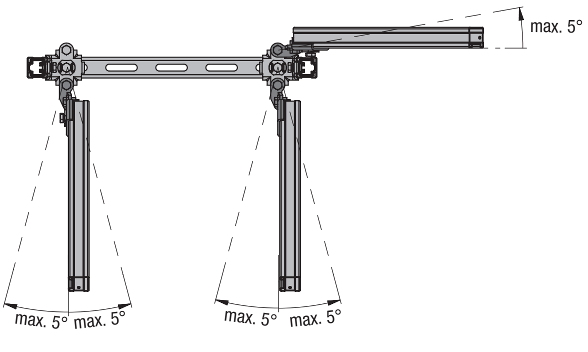
Top view – bracing direction on main axis of the pipe run

Transversal bracing



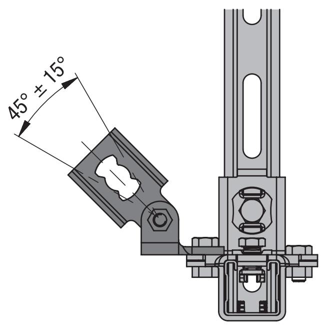
Top view – bracing direction on main axis of the pipe run

4-way bracing



Top view – bracing direction on main axis of the pipe run

Tilt angle – for all bracings

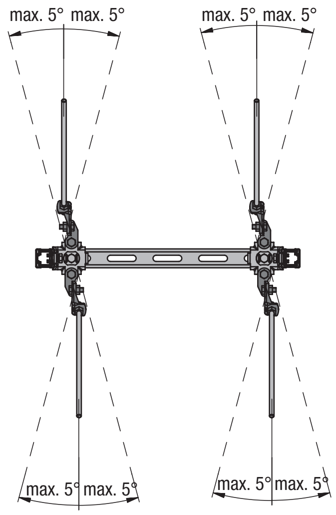


Side view – bracing angle on the horizontal level

Angle variation of bracing with rods

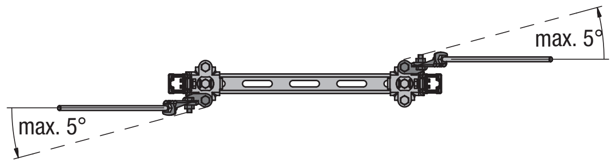
MQS Seismic System

Longitudinal bracing



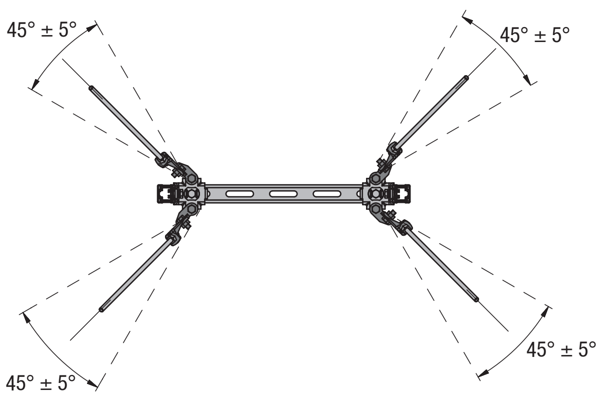
Top view – bracing direction on main axis of the pipe run

Transversal bracing



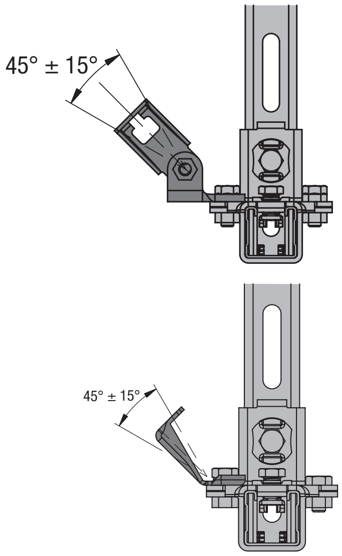
Top view – bracing direction on main axis of the pipe run

4-way bracing



Top view – bracing direction on main axis of the pipe run

Tilt angle – for all bracings

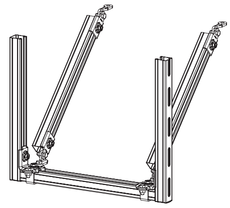


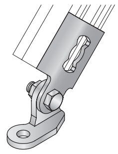
Side view – bracing angle on the horizontal level

Selection Tables – Legend

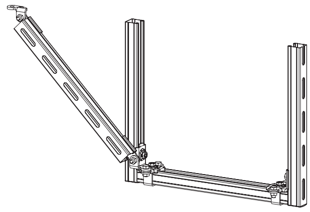
Tables A (A1÷A6) are for Longitudinal or Transversal set-up, for height of trapeze 0.8 m, 1.0 m, 1.2 m
Tables B (B1÷B6) are for 4-way set-up, for height of trapeze 0.8 m, 1.0 m, 1.2m

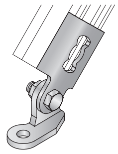
LONGITUDINAL – bracing with MQS-AC



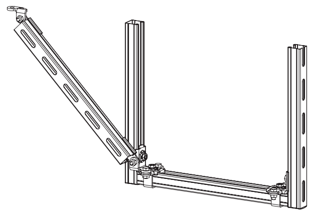
Set-up	Connector
1 Set-up with MQS-W41	
2 Set-up with MQS-W72	
3 Set-up with MQS-W41D	

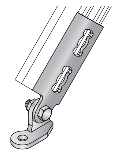
TRANSVERSAL – bracing with MQS-AC



Set-up	Connector
4 Set-up with MQS-W41	
5 Set-up with MQS-W72	
6 Set-up with MQS-W41D	

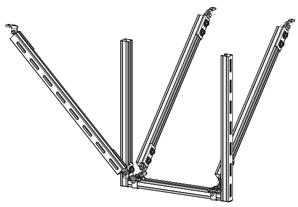
TRANSVERSAL – bracing with MQS-ACD

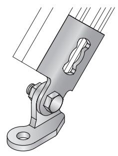


Set-up	Connector
7 Set-up with MQS-W72	
8 Set-up with MQS-W41D	

See Tables A
(A1÷A6)

4-WAY – bracing with MQS-AC

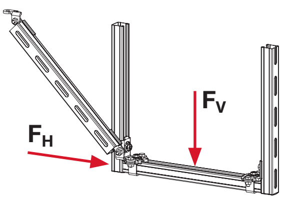


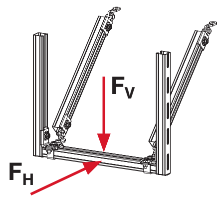
Set-up	Connector
1 Set-up with MQS-W41	
2 Set-up with MQS-W72	
3 Set-up with MQS-W41D	

See Tables B
(B1÷B6)

Vertical Point Load

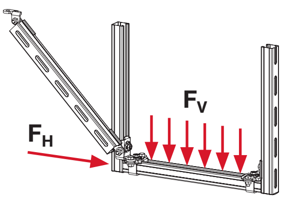
Force concentrated in the middle
of the span on horizontal channel





Vertical Line Load

Uniformly distributed load
on horizontal channel



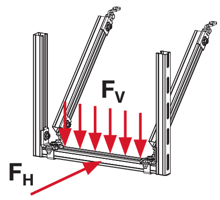
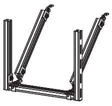


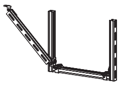
Table N° A1 – point load in the middle of the span, height of the trapeze: 0.8 m

LONGITUNAL with MQS-AC



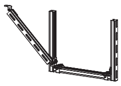
1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4. set-up with MQS-W41
5. set-up with MQS-W72
6. set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



7. set-up with MQS-W72
8. set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	0.65	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.95	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	0.50	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.70	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,
1.50	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
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	1.95	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,
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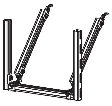
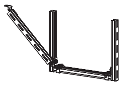
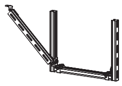
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	2.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,	
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,	
	3.40	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,	
	3.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.20	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	6,8,	6,8,		
	4.60	2,3,	2,3,	2,3,	2,3,	2				
	5.00	2,3,	2,3,	2,3,	2,3,					
2.50	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,		
	2.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,		
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,		
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	4.00	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	5.00	2,3,	2,3,	2,3,	2,3,					
	5.75	2,3,	2,3,	2,3,	2					
	6.25	2,3,	2,3,	2,3,						

Continued on next page...

Table N° A1 – point load in the middle of the span, height of the trapeze: 0.8 m

LONGITUNAL with MQS-AC	TRANSVERSAL with MQS-AC	TRANSVERSAL with MQS-ACD
		
1 set-up with MQS-W41	4 set-up with MQS-W41	7 set-up with MQS-W72
2 set-up with MQS-W72	5 set-up with MQS-W72	8 set-up with MQS-W41D
3 set-up with MQS-W41D	6 set-up with MQS-W41D	

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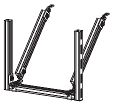
		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
3.00	**0.60**	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	0.90	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.70	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,			
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,			
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,			
	3.90	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,5,7,6,8,	5,7,6,8,				
	4.50	2,3,	2,3,	2,3,	2,3,					
	5.10	2,3,	2,3,	2,3,	2					
	6.60	2,3,	2,3,	2,3,						
	7.50	3	3							
3.50	**0.70**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.10	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.80	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,				
	3.50	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,				
	3.85	2,3,	2,3,6,8,	2,3,6,8,	2,3,6,8,	6,8,				
	4.55	2,3,	2,3,	2,3,	2					
	5.95	2,3,	2,3,	2,3,						
	6.30	2,3,	2,3,	2						
	8.75	3	3							
4.00	**0.80**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.20	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.60	2,3,4,6,8,	2,3,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	4.00	2,3,	2,3,	2,3,	2					
	5.60	2,3,	2,3,	2,3,						
	6.00	2,3,	2,3,	2						
	8.80	3	3							
	9.60	3								
4.50	**0.45**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	2.70	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.15	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	3.60	2,3,	2,3,6,8,	2,3,6,8,	6,8,					
	4.95	2,3,	2,3,	2,3,						
	5.40	2,3,	2,3,	2						
	5.85	2,3,	2,3,							
	8.10	3	3							
	9.00	3								
5.00	**3.00**	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,						
	4.00	2,3,	2,3,	2,3,						
	5.00	2,3,	2,3,	2						
	5.50	2,3,	3							
	7.50	3	3							
	8.50	3								

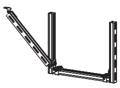
Table N° A2 – uniformly distributed load, height of the trapeze: 0.8 m

LONGITUNAL with MQS-AC



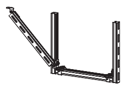
1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4. set-up with MQS-W41
5. set-up with MQS-W72
6. set-up with MQS-W41D

TRANSVERSAL with MQS-ACD

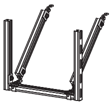
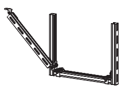
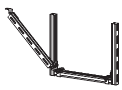


7. set-up with MQS-W72
8. set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	1.15	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.20	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,6,8,	2,3,6,8,
	4.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,
	5.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
2.50	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.00	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
	4.75	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	
	5.50	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
3.00	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.90	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	6.30	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.60	2,3,	2,3,	2,3,	2,3,	3	3			
	6.90	2,3,	3	3	3	3	3			
	7.20	3	3	3	3	3	3			
	7.50	3	3	3	3	3				
3.50	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	1.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	2.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	
	3.85	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	2	
	4.55	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.95	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.30	2,3,	2,3,	2,3,	2,3,	3	3			
	6.65	2,3,	3	3	3	3				
	8.75	3	3	3	3	3				

Continued on next page…

Table N° A2 – uniformly distributed load, height of the trapeze: 0.8 m

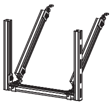
LONGITUNAL with MQS-AC	TRANSVERSAL with MQS-AC	TRANSVERSAL with MQS-ACD
		
1 set-up with MQS-W41	4 set-up with MQS-W41	7 set-up with MQS-W72
2 set-up with MQS-W72	5 set-up with MQS-W72	8 set-up with MQS-W41D
3 set-up with MQS-W41D	6 set-up with MQS-W41D	

... continued from previous page

		Horizontal channel length (m)								
F_V (kN)	$F_{H\ max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
4.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.20	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.60	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.20	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.00	2,3,	2,3,	2,3,	2,3,	3				
	6.40	2,3,	3	3	3	3				
	8.00	3	3	3	3	3				
	9.20	3	3	3	3					
	9.60	3	3							
4.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.60	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	2,3,6,8,	2		
	4.05	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	4.95	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,				
	5.85	2,3,	2,3,	2,3,	3	3				
	7.20	3	3	3	3	3				
	8.55	3	3	3	3					
	9.00	3	3	3						
	9.45	3								
5.00	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	4.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	4.50	2,3,	2,3,	2,3,	2,3,	2,3,	2			
	5.00	2,3,	2,3,	2,3,	2,3,	3				
	5.50	2,3,	2,3,	3	3	3				
	6.50	3	3	3	3	3				
	7.50	3	3	3	3					
	8.00	3	3	3						
	8.50	3	3							

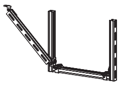
Table N° A3 – point load in the middle of the span, height of the trapeze: 1.0 m

LONGITUNAL with MQS-AC



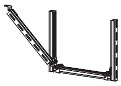
1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4. set-up with MQS-W41
5. set-up with MQS-W72
6. set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



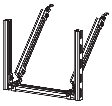
7. set-up with MQS-W72
8. set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	0.65	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.95	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	0.50	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.70	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,
1.50	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.95	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,
	2.55	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,
	2.85	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	2.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,	
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,	
	3.40	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,	
	3.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.20	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,6,8,	2,3,5,7,6,8,	5,7,6,8,	6,8,		
	4.60	2,3,	2,3,	2,3,	2,3,	2				
	5.00	2,3,	2,3,	2,3,	2,3,					
2.50	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,		
	2.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,		
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,		
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	4.00	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	5.00	2,3,	2,3,	2,3,	2,3,					
	5.75	2,3,	2,3,	2,3,	2					
	6.25	2,3,	2,3,	2,3,						

Continued on next page...

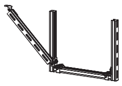
Table N° A3 – point load in the middle of the span, height of the trapeze: 1.0 m

LONGITUNAL with MQS-AC



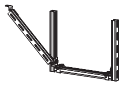
1 set-up with MQS-W41
2 set-up with MQS-W72
3 set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4 set-up with MQS-W41
5 set-up with MQS-W72
6 set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



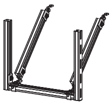
7 set-up with MQS-W72
8 set-up with MQS-W41D

... continued from previous page

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
3.00	**0.60**	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	0.90	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.70	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,			
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,			
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,			
	3.90	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,			
	4.50	2,3,	2,3,	2,3,	2,3,					
	5.10	2,3,	2,3,	2,3,	2					
	6.60	2,3,	2,3,	2,3,						
	6.90	2,3,	3							
	7.50	3	3							
3.50	**0.70**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.10	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.80	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,				
	3.50	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,				
	3.85	2,3,	2,3,6,8,	2,3,6,8,	2,3,6,8,	6,8,				
	4.55	2,3,	2,3,	2,3,	2					
	5.95	2,3,	2,3,	2,3,						
	6.30	2,3,	2,3,	2						
	8.75	3	3							
4.00	**0.80**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.20	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.60	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	4.00	2,3,	2,3,	2,3,	2					
	5.60	2,3,	2,3,	2,3,						
	6.00	2,3,	2,3,	2						
	8.80	3	3							
	9.60	3								
4.50	**0.45**	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	2.70	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.15	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	3.60	2,3,4,	2,3,6,8,	2,3,6,8,	6,8,					
	4.95	2,3,	2,3,	2,3,						
	5.40	2,3,	2,3,	2						
	5.85	2,3,	2,3,							
	8.10	3	3							
	9.00	3								
5.00	**3.00**	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,						
	4.00	2,3,	2,3,	2,3,						
	5.00	2,3,	2,3,	2						
	5.50	2,3,	3							
	7.50	3	3							
	8.50	3								

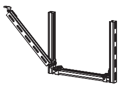
Table N° A4 – uniformly distributed load, height of the trapeze: 1.0 m

LONGITUNAL with MQS-AC



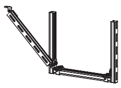
1 set-up with MQS-W41
2 set-up with MQS-W72
3 set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4 set-up with MQS-W41
5 set-up with MQS-W72
6 set-up with MQS-W41D

TRANSVERSAL with MQS-ACD

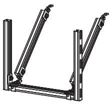
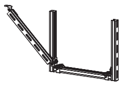
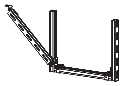


7 set-up with MQS-W72
8 set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	1.15	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.40	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.20	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,
	5.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
2.50	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.00	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
	4.75	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	
	5.50	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
3.00	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.90	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	6.30	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.60	2,3,	2,3,	2,3,	2,3,	3	3			
	6.90	2,3,	3	3	3	3	3			
	7.20	3	3	3	3	3	3			
	7.50	3	3	3	3	3				
3.50	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	1.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	2.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	
	3.85	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,6,8,	2,6,8,	
	4.55	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.95	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.30	2,3,	2,3,	2,3,	2,3,	3	3			
	6.65	2,3,	3	3	3	3				
	8.75	3	3	3	3	3				

Continued on next page...

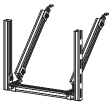
Table N° A4 – uniformly distributed load, height of the trapeze: 1.0 m

LONGITUNAL with MQS-AC	TRANSVERSAL with MQS-AC	TRANSVERSAL with MQS-ACD
		
1 set-up with MQS-W41	4 set-up with MQS-W41	7 set-up with MQS-W72
2 set-up with MQS-W72	5 set-up with MQS-W72	8 set-up with MQS-W41D
3 set-up with MQS-W41D	6 set-up with MQS-W41D	

... continued from previous page

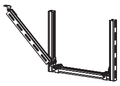
		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
4.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.20	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.60	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.20	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.00	2,3,	2,3,	2,3,	2,3,	3				
	6.40	2,3,	3	3	3	3				
	8.00	3	3	3	3	3				
	9.20	3	3	3	3					
	9.60	3	3							
4.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.60	2,3,	2,3,4,6,8,	2,3,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,6,8,	2		
	4.05	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	4.95	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,				
	5.85	2,3,	2,3,	2,3,	3	3				
	7.20	3	3	3	3	3				
	8.55	3	3	3	3					
	9.00	3	3	3						
	9.45	3								
5.00	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	4.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	4.50	2,3,	2,3,	2,3,	2,3,	2,3,	2			
	5.00	2,3,	2,3,	2,3,	2,3,	3				
	5.50	2,3,	2,3,	3	3	3				
	6.50	3	3	3	3	3				
	7.50	3	3	3	3					
	8.00	3	3	3						
	8.50	3	3							

Table N° A5 – point load in the middle of the span, height of the trapeze: 1.2 m



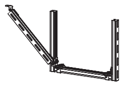
LONGITUNAL with MQS-AC

1 set-up with MQS-W41
2 set-up with MQS-W72
3 set-up with MQS-W41D



TRANSVERSAL with MQS-AC

4 set-up with MQS-W41
5 set-up with MQS-W72
6 set-up with MQS-W41D



TRANSVERSAL with MQS-ACD

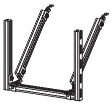
7 set-up with MQS-W72
8 set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	0.65	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	0.95	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	0.50	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.70	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.10	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,
1.50	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	1.95	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,
	2.55	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,
	2.85	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	1.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	2.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,	
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,	
	3.40	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,	
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,	5,7,	
	4.20	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,6,8,		
	4.60	2,3,	2,3,	2,3,	2,3,	2				
	5.00	2,3,	2,3,	2,3,	2,3,					
2.50	0.75	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	1.00	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	2.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,		
	2.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,		
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,		
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	4.00	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,6,8,	5,7,		
	5.00	2,3,	2,3,	2,3,	2,3,					
	5.75	2,3,	2,3,	2,3,	2					
	6.25	2,3,	2,3,	2,3,						

Continued on next page…

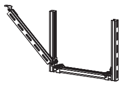
Table N° A5 – point load in the middle of the span, height of the trapeze: 1.2 m

LONGITUNAL with MQS-AC



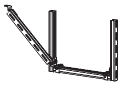
1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4. set-up with MQS-W41
5. set-up with MQS-W72
6. set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



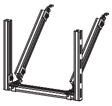
7. set-up with MQS-W72
8. set-up with MQS-W41D

... continued from previous page

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
3.00	0.60	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	0.90	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.10	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,			
	2.70	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,			
	3.30	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	5,7,			
	3.60	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,			
	3.90	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,	5,7,			
	4.50	2,3,	2,3,	2,3,	2,3,					
	5.10	2,3,	2,3,	2,3,	2					
	6.60	2,3,	2,3,	2,3,						
	6.90	2,3,	3							
	7.50	3	3							
3.50	0.70	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.10	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,				
	2.80	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,				
	3.15	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,				
	3.50	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,6,8,				
	3.85	2,3,	2,3,6,8,	2,3,6,8,	2,3,6,8,	6,8,				
	4.55	2,3,	2,3,	2,3,	2					
	5.95	2,3,	2,3,	2,3,						
	6.30	2,3,	2,3,	2						
	6.65	2,3,	3							
	8.75	3	3							
4.00	0.80	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.20	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.60	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	4.00	2,3,	2,3,	2,3,	2					
	5.60	2,3,	2,3,	2,3,						
	6.00	2,3,	2,3,	2						
	8.80	3	3							
	9.60	3								
4.50	0.45	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	2.70	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,					
	3.15	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,					
	3.60	2,3,4,	2,3,6,8,	2,3,6,8,	6,8,					
	4.95	2,3,	2,3,	2,3,						
	5.40	2,3,	2,3,	2						
	5.85	2,3,	2,3,							
	8.10	3	3							
	9.00	3								
5.00	3.00	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,						
	4.00	2,3,	2,3,	2,3,						
	5.00	2,3,	2,3,	2						
	5.50	2,3,	3							
	7.50	3	3							
	8.50	3								

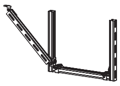
Table N° A6 – uniformly distributed load, height of the trapeze: 1.2 m

LONGITUNAL with MQS-AC



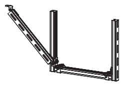
1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4. set-up with MQS-W41
5. set-up with MQS-W72
6. set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



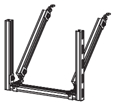
7. set-up with MQS-W72
8. set-up with MQS-W41D

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	1.15	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.25	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.00	1.10	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	2.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
1.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,
	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
	3.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,
2.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,
	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.40	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,
	3.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.00	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.20	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	4.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,
	5.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
2.50	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,
	3.75	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.00	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,
	4.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2
	4.75	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	
	5.50	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.25	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
3.00	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.60	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	3.90	2,3,	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2	
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	6.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	6.30	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.60	2,3,	2,3,	2,3,	2,3,	3	3			
	6.90	2,3,	3	3	3	3	3			
	7.20	3	3	3	3	3	3			
	7.50	3	3	3	3	3				
3.50	1.05	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	1.75	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,
	2.80	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	
	3.50	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,6,8,	
	3.85	2,3,	2,3,4,6,8,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,6,8,	
	4.55	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,		
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.95	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.30	2,3,	2,3,	2,3,	2,3,	3	3			
	6.65	2,3,	3	3	3	3				
	8.75	3	3	3	3	3				

Continued on next page...

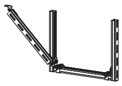
Table N° A6 – uniformly distributed load, height of the trapeze: 1.2 m

LONGITUNAL with MQS-AC



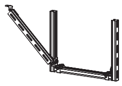
1 set-up with MQS-W41
2 set-up with MQS-W72
3 set-up with MQS-W41D

TRANSVERSAL with MQS-AC



4 set-up with MQS-W41
5 set-up with MQS-W72
6 set-up with MQS-W41D

TRANSVERSAL with MQS-ACD



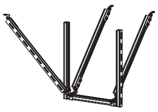
7 set-up with MQS-W72
8 set-up with MQS-W41D

... continued from previous page

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
4.00	0.80	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.20	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,	
	3.60	2,3,4,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	5,7,	
	4.80	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	5.20	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.60	2,3,	2,3,	2,3,	2,3,	2,3,	3			
	6.00	2,3,	2,3,	2,3,	2,3,	3				
	6.40	2,3,	3	3	3	3				
	8.00	3	3	3	3	3				
	9.20	3	3	3	3					
	9.60	3	3							
4.50	0.90	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.15	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,5,7,		
	3.60	2,3,	2,3,4,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2		
	4.05	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,	2		
	4.95	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	5.40	2,3,	2,3,	2,3,	2,3,	2,3,				
	5.85	2,3,	2,3,	2,3,	3	3				
	7.20	3	3	3	3	3				
	8.55	3	3	3	3					
	9.00	3	3	3						
	9.45	3								
5.00	1.00	1,2,3,4,5,7,6,8,	1,2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	3.00	2,3,4,5,7,6,8,	2,3,4,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,	2,3,5,7,6,8,			
	4.00	2,3,	2,3,	2,3,	2,3,	2,3,	2,3,			
	4.50	2,3,	2,3,	2,3,	2,3,	2,3,	2			
	5.00	2,3,	2,3,	2,3,	2,3,	3				
	5.50	2,3,	2,3,	3	3	3				
	6.50	3	3	3	3	3				
	7.50	3	3	3	3					
	8.00	3	3	3						
	8.50	3	3							

Table N° B1 – point load in the middle of the span, height of the trapeze: 0.8 m

4-WAY with MQS-AC



1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

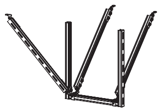
		Horizontal channel length (m)								
F_V (kN)	**$F_{H\,max}$ (kN)**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**
0.50	**1.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	**1.20**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	1.60	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	2.10	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
1.50	**1.80**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
	2.25	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3
	2.70	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3
	3.15	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	3.45	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
2.00	**2.20**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
	2.80	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2	
	3.20	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2	
	3.40	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2	
2.50	**2.50**	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2		
	3.00	1,2,3	2.3	2.3	2.3	2.3	2.3	2		
	3.50	2.3	2.3	2.3	2.3	2.3	2.3	2		
3.00	**2.10**	1,2,3	1,2,3	2.3	2.3	2.3	2			
	2.70	1,2,3	2.3	2.3	2.3	2.3	2			
	3.30	2.3	2.3	2.3	2.3	2.3	2			
3.50	**2.45**	1,2,3	2.3	2.3	2.3	2.3				
	3.50	2.3	2.3	2.3	2.3	2.3				
4.00	**2.40**	1,2,3	2.3	2.3	2.3					
	3.20	2.3	2.3	2.3	2.3					
4.50	**2.25**	1,2,3	2.3	2.3	2.3					
	3.15	2.3	2.3	2.3	2.3					
5.00	**3.00**	2.3	2.3	2.3						

Table N° B2 – uniformly distributed load, height of the trapeze: 0.8 m

		Horizontal channel length (m)								
F_V (kN)	**$F_{H\,max}$ (kN)**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**
0.50	**1.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	**2.50**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.50	**2.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
	2.70	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	3.45	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
2.00	**2.00**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	2.80	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	3.40	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
2.50	**2.75**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
3.00	**3.30**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2
3.50	**1.75**	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	
4.00	**3.20**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
4.50	**3.15**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2		
5.00	**3.00**	1,2,3	1,2,3	2.3	2.3	2.3	2.3			

Table N° B3 – point load in the middle of the span, height of the trapeze: 1.0 m

4-WAY with MQS-AC



1. set-up with MQS-W41
2. set-up with MQS-W72
3. set-up with MQS-W41D

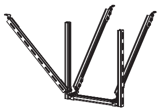
		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	**1.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	**1.20**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	1.60	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	2.10	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
	2.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
1.50	**1.80**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
	2.25	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3
	2.70	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3
	3.15	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	3.45	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
2.00	**2.20**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
	2.80	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2	
	3.20	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2	
	3.40	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2	
2.50	**2.50**	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2		
	3.00	1,2,3	2.3	2.3	2.3	2.3	2.3	2		
	3.50	2.3	2.3	2.3	2.3	2.3	2.3	2		
3.00	**2.10**	1,2,3	1,2,3	2.3	2.3	2.3	2			
	2.70	1,2,3	2.3	2.3	2.3	2.3	2			
	3.30	2.3	2.3	2.3	2.3	2.3	2			
3.50	**2.45**	1,2,3	2.3	2.3	2.3	2.3				
	3.50	2.3	2.3	2.3	2.3	2.3				
4.00	**2.40**	1,2,3	2.3	2.3	2.3					
	3.20	2.3	2.3	2.3	2.3					
4.50	**2.25**	1,2,3	2.3	2.3	2.3					
	3.15	2.3	2.3	2.3	2.3					
5.00	**3.00**	2.3	2.3	2.3						

Table N° B4 – uniformly distributed load, height of the trapeze: 1.0 m

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	**1.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	**2.50**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.50	**2.25**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
	2.70	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	3.45	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
2.00	**2.00**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	2.80	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	3.40	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
2.50	**2.75**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
3.00	**3.30**	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2
3.50	**1.75**	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	
4.00	**3.20**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
4.50	**3.15**	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2		
5.00	**3.00**	1,2,3	1,2,3	2.3	2.3	2.3	2.3			

Table N° B5 – point load in the middle of the span, height of the trapeze: 1.2 m

4-WAY with MQS-AC



1 set-up with MQS-W41
2 set-up with MQS-W72
3 set-up with MQS-W41D

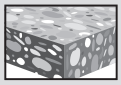
		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	1.25	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	1.20	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	1.60	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	2.10	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
	2.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
1.50	1.80	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
	2.25	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3
	2.70	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3
	3.15	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	3.45	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
2.00	2.20	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
	2.80	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2.3	2	
	3.20	1,2,3	2.3	2.3	2.3	2.3	2.3	2.3	2	
	3.40	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2	
2.50	2.50	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2		
	3.00	1,2,3	2.3	2.3	2.3	2.3	2.3	2		
	3.50	2.3	2.3	2.3	2.3	2.3	2.3	2		
3.00	2.10	1,2,3	1,2,3	2.3	2.3	2.3	2			
	2.70	1,2,3	2.3	2.3	2.3	2.3	2			
	3.30	2.3	2.3	2.3	2.3	2.3	2			
3.50	2.45	1,2,3	2.3	2.3	2.3	2.3				
	3.50	2.3	2.3	2.3	2.3	2.3				
4.00	2.40	1,2,3	2.3	2.3	2.3					
	3.20	2.3	2.3	2.3	2.3					
4.50	2.25	1,2,3	2.3	2.3	2.3					
	3.15	2.3	2.3	2.3	2.3					
5.00	3.00	2.3	2.3	2.3						

Table N° B6 – uniformly distributed load, height of the trapeze: 1.2 m

		Horizontal channel length (m)								
F_V (kN)	$F_{H\,max}$ (kN)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.50	1.25	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.00	2.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
1.50	2.25	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
	2.70	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	3.45	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
2.00	2.00	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3
	2.80	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3
	3.40	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
2.50	2.75	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3
3.00	3.30	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2
3.50	1.75	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2
	3.50	1,2,3	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	
4.00	3.20	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2.3	2	
4.50	3.15	1,2,3	1,2,3	1,2,3	2.3	2.3	2.3	2		
5.00	3.00	1,2,3	1,2,3	2.3	2.3	2.3	2.3			

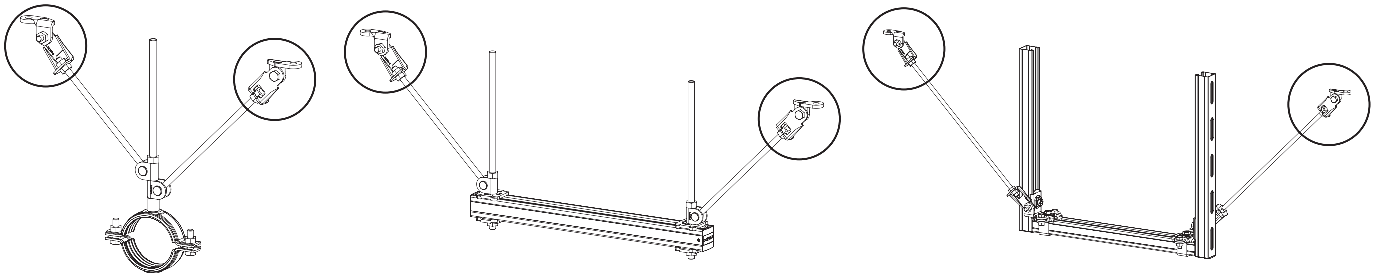
Structural attachment on solid concrete
Fastening of seismic rod bracing

Base material

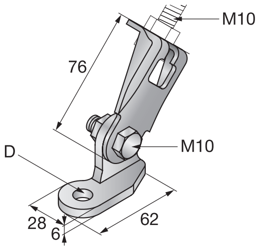


Solid concrete

Applications:

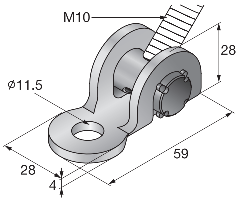


Seismic hinge MQS-AB



	Stud anchor	Screw anchor	Chemical anchor
MQS-AB-8 Item n.: 2083730	**HST-M8x75** 3) Item n.: 371581	**HUS-H 6x80** 3) Item n.: 416737	**HIT-HY 200-A + HIT-V M8x80** 1) Item n.: 2022696 + 387054 or **HIT-HY 200-A + HIT-Z M8x80** 2) Item n.: 2022696 + 2018364
MQS-AB-10 Item n.: 2083731	**HST-M10x90** 2) Item n.: 371584	**HUS-H 8x90** 1) Item n.: 368731	**HIT-HY 200-A + HIT-V M10x95** 1) Item n.: 2022696 + 387057 or **HIT-HY 200-A + HIT-Z M10x95** 2) Item n.: 2022696 + 2018367
MQS-AB-12 Item n.: 2083732	**HST-M12x115** 2) Item n.: 371587	**HUS-H 10x90** 1) Item n.: 401439	**HIT-HY 200-A + HIT-V M12x120** 2) Item n.: 2022696 + 387147 or **HIT-HY 200-A + HIT-Z M12x105** 2) Item n.: 2022696 + 2018411

Seismic hinge MQS-CH



	Stud anchor	Screw anchor	Chemical anchor
MQS-CH Item n.: 2083741	**HST-M10x90** 2) Item n.: 371584	**HUS-H 8x90** 1) Item n.: 368731	**HIT-HY 200-A + HIT-V M10x95** 1) Item n.: 2022696 + 387057 or **HIT-HY 200-A + HIT-Z M10x95** 2) Item n.: 2022696 + 2018367

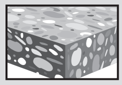
1) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1
2) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1 and C2
3) approved anchor according to the European Guideline ETAG 001-1, Option 1

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

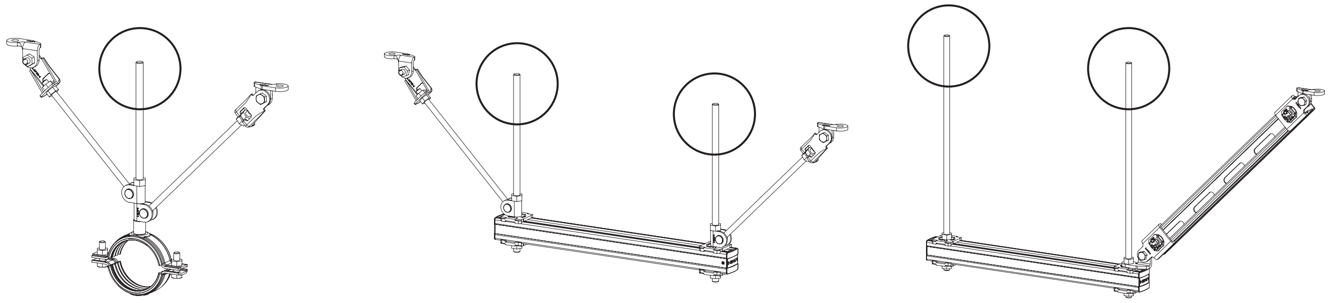
Structural attachment on solid concrete
Fastening of rod hanging

Base material



Solid concrete

Applications:



Fastening of threaded rod

	Stud anchor	Chemical anchor
Threaded rod M8 Item n.: according to length	**HST-M8x75** [3] **+ M8 coupler** Item n.: 371581 + 216703	**HIT-HY 200-A + threaded rod** [1] Item n.: 2022696
Threaded rod M10 Item n.: according to length	**HST-M10x90** [2] **+ M10 coupler** Item n.: 371584 + 216704	**HIT-HY 200-A + threaded rod** [1] Item n.: 2022696
Threaded rod M12 Item n.: according to length	**HST-M12x115** [2] **+ M12 coupler** Item n.: 371587 + 216705	**HIT-HY 200-A + threaded rod** [1] Item n.: 2022696
Threaded rod M16 Item n.: according to length	**HST-M16x140** [2] **+ M16 coupler** Item n.: 371593 + 216706	**HIT-HY 200-A + threaded rod** [1] Item n.: 2022696

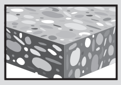
1) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1
2) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1 and C2
3) approved anchor according to the European Guideline ETAG 001-1, Option 1

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

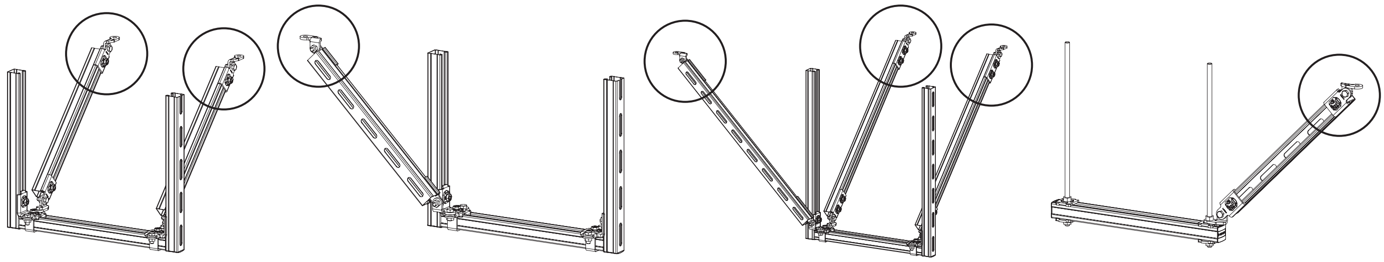
Structural attachment on solid concrete
Fastening of seismic channel bracing

Base material

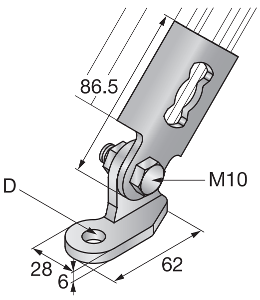


Solid concrete

Applications:



Seismic hinge MQS-AC/-ACD



	Stud anchor	Screw anchor	Chemical anchor
MQS-AC-10/-ACD-10 Item n.: 2083725 / 2083727	**HST-M10x90** 2) Item n.: 371584	**HUS-H 8x90** 1) Item n.: 368731	**HIT-HY 200-A + HIT-V M10x95** 1) Item n.: 2022696 + 387057 or **HIT-HY 200-A + HIT-Z M10x95** 2) Item n.: 2022696 + 2018367
MQS-AC-12/-ACD-12 Item n.: 2083726 / 2083728	**HST-M12x115** 2) Item n.: 371587	**HUS-H 10x90** 1) Item n.: 401439	**HIT-HY 200-A + HIT-V M12x120** 1) Item n.: 2022696 + 387147 or **HIT-HY 200-A + HIT-Z M12x105** 2) Item n.: 2022696 + 2018411

1) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1
2) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1 and C2

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

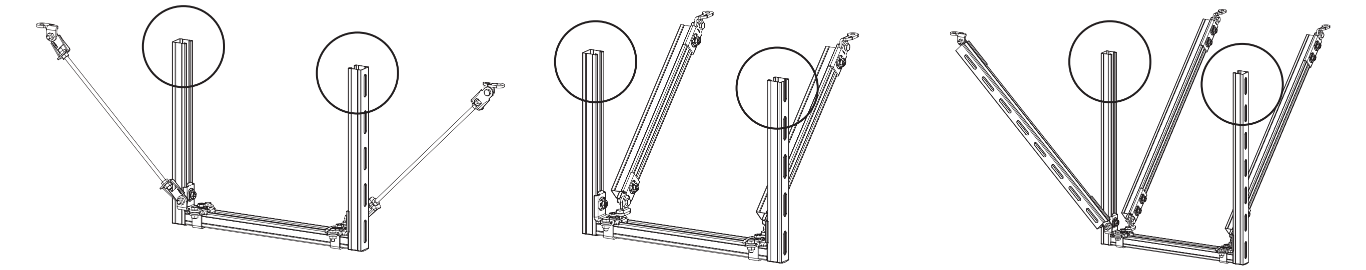
MQS System
Seismic Designed Solutions

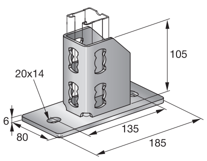
Structural attachment on solid concrete
Fastening of channel hanging

Base material

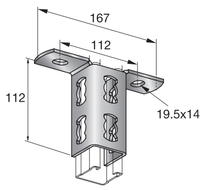
Solid concrete

Applications:

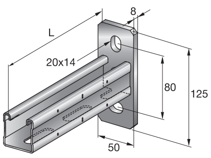




Base MQP-21-72
Item n.: 369651



Connector MQV-2/2D-14
Item n.: 369639



Bracket MQK
Item n.: according bracket type and length

Stud anchor	Screw anchor	Chemical anchor
HST-M10x90 2) Item n.: 371584	**HUS-H 8x90** 1) Item n.: 368731	**HIT-HY 200-A + HIT-V M10x95** 1) Item n.: 2022696 + 387057 or **HIT-HY 200-A + HIT-Z M10x95** 2) Item n.: 2022696 + 2018367
HST-M12x115 2) Item n.: 371587	**HUS-H 10x90** 1) Item n.: 401439	**HIT-HY 200-A + HIT-V M12x120** 1) Item n.: 2022696 + 387147 or **HIT-HY 200-A + HIT-Z M12x105** 2) Item n.: 2022696 + 2018411

1) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1
2) approved anchor according to the new European Guideline ETAG 001 Annex E, seismic category ETA C1 and C2

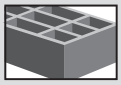
General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

Hilti strongly advises the Customer to verify the respective application by consultation and calculation of an structural engineer for the compliance of the product with applicable norms and standards. The non-involvement of a structure engineer will lead to a release of Hilti's liability. It is required that the Product is used strictly according to the applicable Hilti Instruction For Use and within the application limits specified in the Hilti Technical Data Sheets, the technical specifications and supporting Product literature, and the relevant application limits were not exceeded at any time.

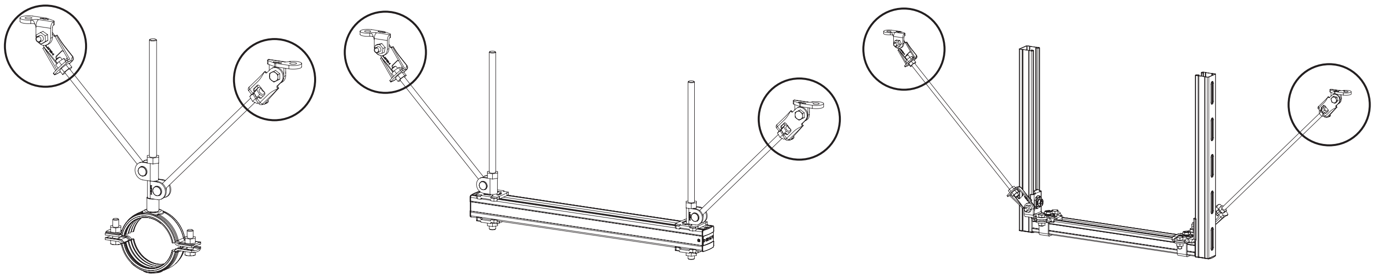
Structural attachment on hollow brick
Fastening of seismic rod bracing

Base material

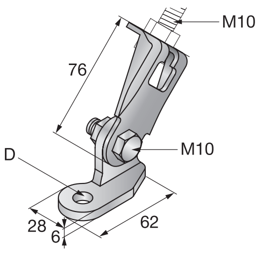


Hollow brick

Applications:

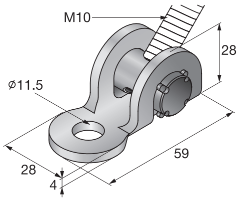


Seismic hinge MQS-AB



	Chemical anchor		
	Mortar	**Anchor rod or threaded rod**	**Mesh sleeve**
MQS-AB-8 Item n.: 2083730	**HIT-HY 70** Item n.: 383677	**HIT-V-5.8 M8x80 / x110 or AM8 8.8 rod** Item n.: 387054 / 387055 or 407496	**HIT-SC M16x...** Item n.: 375981 or 375982
MQS-AB-10 Item n.: 2083731		**HIT-V-5.8 M10x95 / x115 / x130 or AM10 8.8 rod** Item n.: 387057 / 387146 / 387058 or 407497	**HIT-SC M18x...** Item n.: 360485 or 360486
MQS-AB-12 Item n.: 2083732		**HIT-V-5.8 M12x120 / x150 or AM12 8.8 rod** Item n.: 387147 / 387061 or 407498	**HIT-SC M22x...** Item n.: 273662 or 284511

Seismic hinge MQS-CH



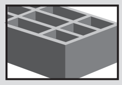
	Chemical anchor		
	Mortar	**Anchor rod or threaded rod**	**Mesh sleeve**
MQS-CH Item n.: 2083741	**HIT-HY 70** Item n.: 383677	**HIT-V-5.8 M10x95 / x115 / x130 or AM10 8.8 rod** Item n.: 387057 / 387146 / 387058 or 407497	**HIT-SC M18x...** Item n.: 360485 or 360486

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

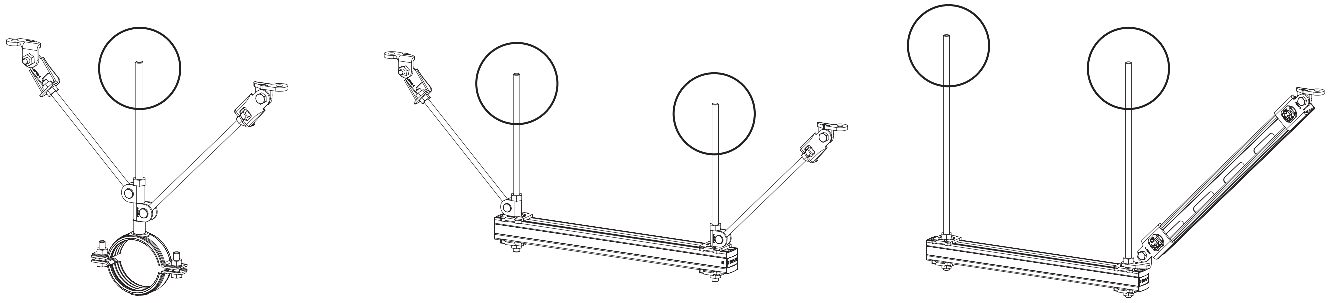
Structural attachment on hollow brick
Fastening of rod hanging

Base material



Hollow brick

Applications:



Fastening of threaded rod

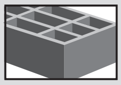
	Chemical anchor				
	Mortar	Fastening of threaded rod		Fastening with internally threaded sleeve	
		Threaded rod	Mesh sleeve	Internally threaded sleeve	Mesh sleeve
Threaded rod M8 Item n.: according to length	**HIT-HY 70** Item n.: 383677	**AM8x...**	**HIT-SC M16x...** Item n.: 375981 or 375982	**HIT-IC M8** Item n.: 47935	**HIT-SC M16x...** Item n.: 375981 or 375982
Threaded rod M10 Item n.: according to length		**AM10x...**	**HIT-SC M18x...** Item n.: 360485 or 360486	**HIT-IC M10** Item n.: 47936	**HIT-SC M18x...** Item n.: 360485 or 360486
Threaded rod M12 Item n.: according to length		**AM12x...**	**HIT-SC M22x...** Item n.: 273662 or 284511	**HIT-IC M12** Item n.: 47937	**HIT-SC M22x...** Item n.: 273662 or 284511
Threaded rod M16 Item n.: according to length		Fastening with base plate MQS 2-M16 (Item n. 246915) and 2 anchors composed of M10 threaded rod and HIT-SC M18 mesh sleeve is recommended		-	-

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

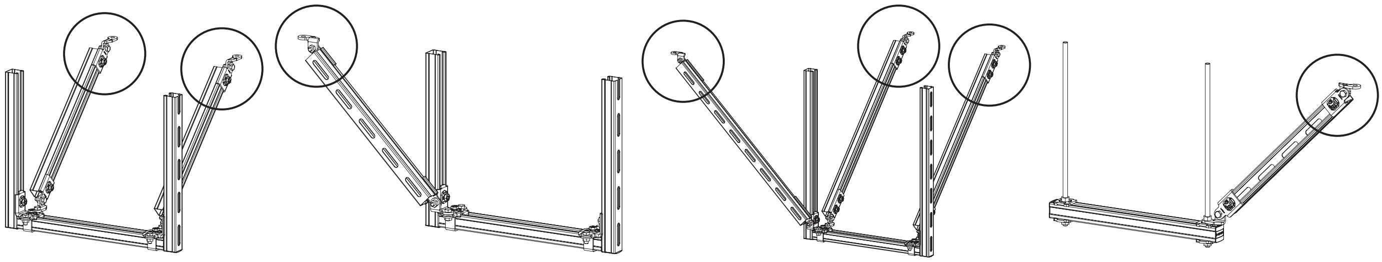
Structural attachment on hollow brick
Fastening of seismic channel bracing

Base material

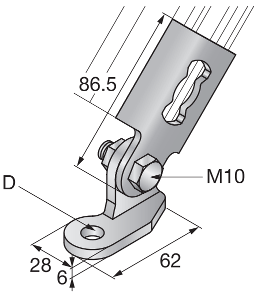


Hollow brick

Applications:



Seismic hinge MQS-AC/-ACD



	Chemical anchor		
	Mortar	**Anchor rod or threaded rod**	**Mesh sleeve**
MQS-AC-10/-ACD-10 Item n.: 2083725 / 2083727	**HIT-HY 70** Item n.: 383677	**HIT-V-5.8 M10x95 / x115 / x130 or AM10 8.8 rod** Item n.: 387057 / 387146 / 387058 or 407497	**HIT-SC M18x...** Item n.: 360485 or 360486
MQS-AC-12/-ACD-12 Item n.: 2083726 / 2083728		**HIT-V-5.8 M12x120 / x150 or AM12 8.8 rod** Item n.: 387147 / 387061 or 407498	**HIT-SC M22x...** Item n.: 273662 or 284511

General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

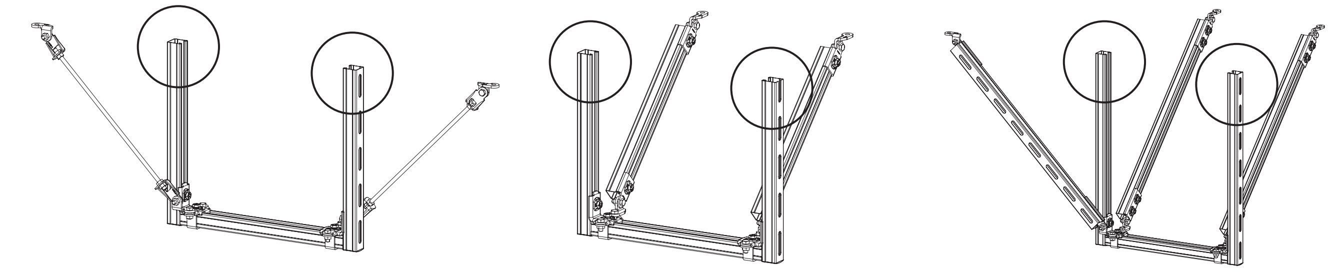
MQS System
Seismic Designed Solutions

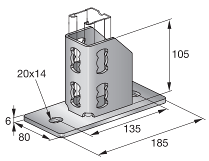
Structural attachment on hollow brick
Fastening of channel hanging

Base material

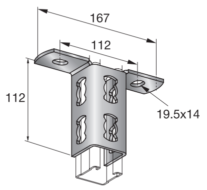
Hollow brick

Applications:

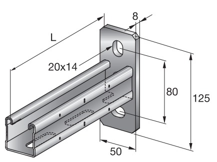




Base MQP-21-72
Item n.: 369651



Connector MQV-2/2D-14
Item n.: 369639



Bracket MQK
Item n.: according bracket type and length

Chemical anchor		
Mortar	**Anchor rod or threaded rod**	**Mesh sleeve**
HIT-HY 70 Item n.: 383677	**HIT-V-5.8 M10x95 / x115 / x130 or AM10 8.8 rod** Item n.: 387057 / 387146 / 387058 or 407497	**HIT-SC M18x...** Item n.: 360485 or 360486
	HIT-V-5.8 M12x120 / x150 or AM12 8.8 rod Item n.: 387147 / 387061 or 407498	**HIT-SC M22x...** Item n.: 273662 or 284511

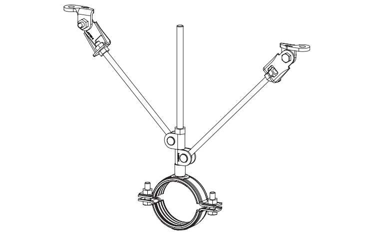
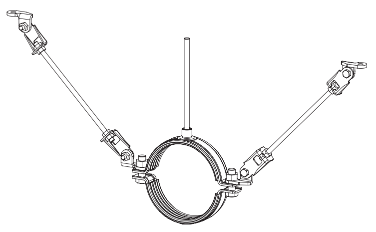
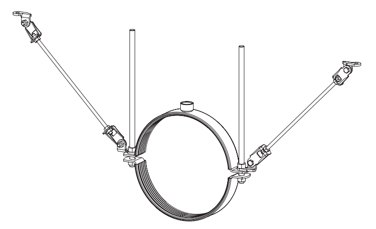
General Design Notes
The anchoring system must be verified separately through the software **Hilti PROFIS Anchor** or using the **Hilti Fastening Technology Manual**, considering the real forces acting on the anchor and the actual boundary conditions for the specific application, such as, for non-exhaustive example, the strength class of the concrete, the presence of edges close to the anchor and the base material thickness.

MQS System
Seismic Designed Solutions

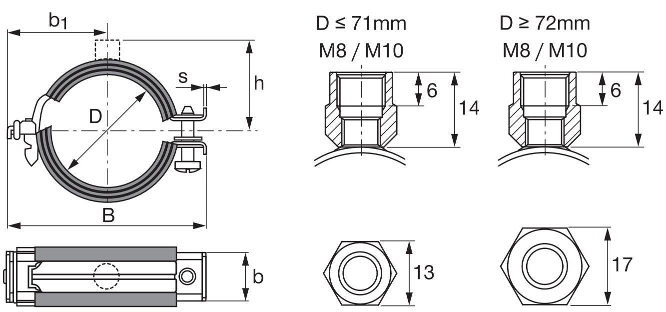
Trade attachments
Piping – single pipe

MQS Seismic System

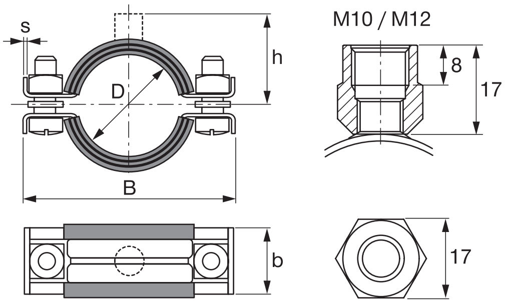
Recommendations on type of application and type of pipe ring for the correct transfer of horizontal seismic loads, according to typicals in Chapter 3

Application		Pipe	
		Dimension	Pipe ring
Single rod hanging – seismic bracing installed on vertical rod		∅ < 4"	MPN-RC 1) MP-MI 2)
Single rod hanging – seismic bracing installed on pipe ring flanges		4" ≤ ∅ < 324 mm	MP-MX 3) MP-MXI 4)
Double rod hanging – seismic bracing installed on pipe ring flanges		∅ ≥ 324 mm	MP-MX 3) MP-MXI 4)

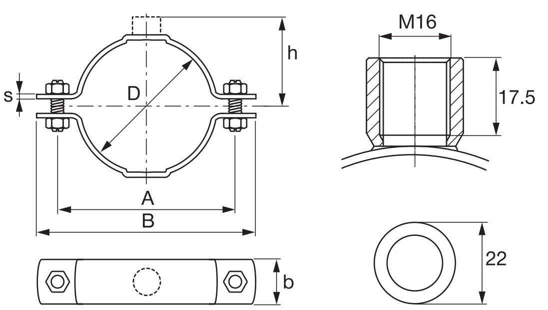
1) MPN-RC pipe rings



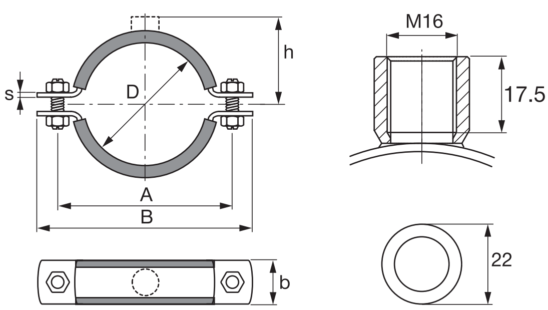
2) MP-MI pipe rings



3) MP-MX pipe rings



4) MP-MXI pipe rings

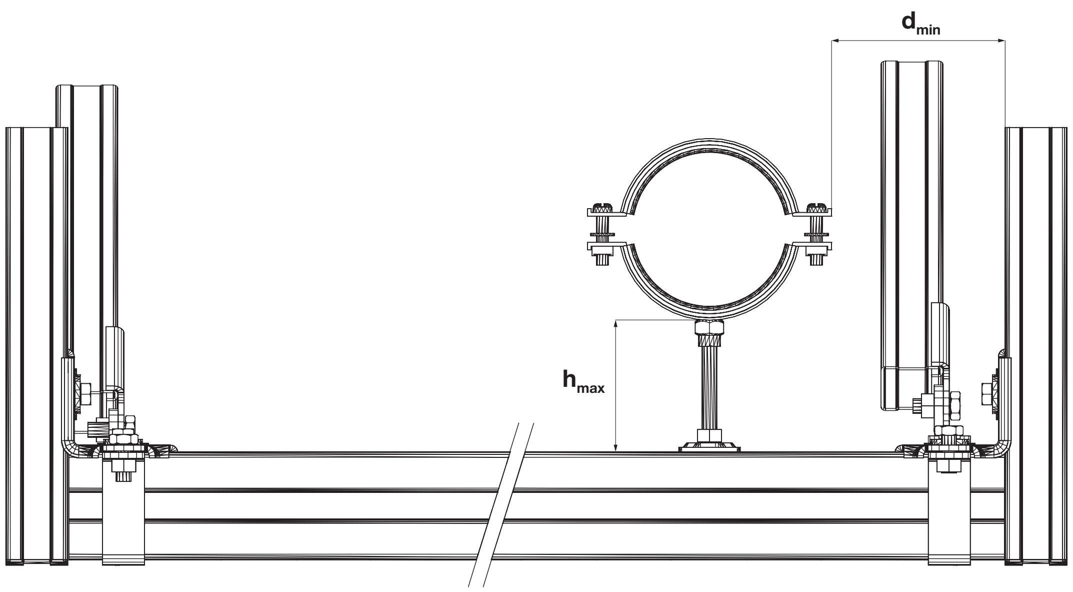


Trade attachments
Piping – multiple pipe

MQS
Seismic System

Recommendations on type of application and type of pipe ring for the correct transfer of horizontal seismic loads, according to typicals in Chapter 3

Based on pipe ring type (and pipe diameter as a consequence) table shows:
- threaded rod diameter recommended, to fix pipe-ring to the channel
- Pipe ring saddle nut (MQA type), for the fixation of the rod to the channel
- Max distance **h** from the connection boss to the horizontal channel
- Min distance **d** from the vertical channel (for the longitudinal bracing installation)

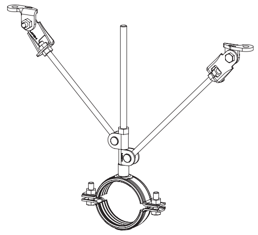
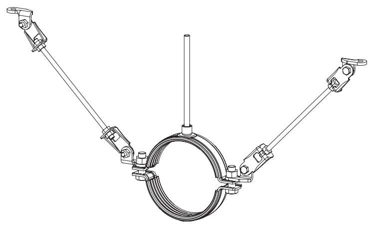
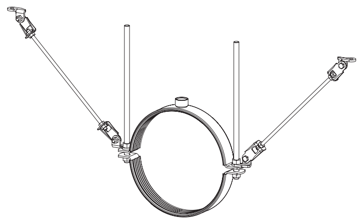


Pipe ring	Rod diameter	Pipe ring saddle	h_{max} [mm]	d_{min} [mm]
MPN-RC	M10	MQA-M10	100	100
MP-MI	M10/M12	MQA-M10/M12	100	100
MP-MX(I)	M16	MQA-M16	100	100

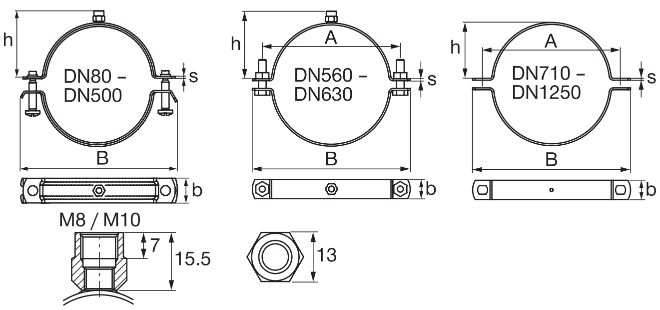
Trade attachments
Ventilation air ducts (without insulation)

MQS
Seismic System

Recommendations on type of application and type of ventilation pipe ring for the correct transfer of horizontal seismic loads, according to typicals in Chapter 3

Application		Circular air duct (without sound insulation)	
		Dimension	Pipe ring
Single rod hanging – seismic bracing installed on vertical rod		⌀ < DN 560	MV-P
Single rod hanging – seismic bracing installed on pipe ring flanges		DN 560 ≤ ⌀ ≤ DN 630	MV-P
Double rod hanging – seismic bracing installed on pipe ring flanges		⌀ > DN 630	MV-P

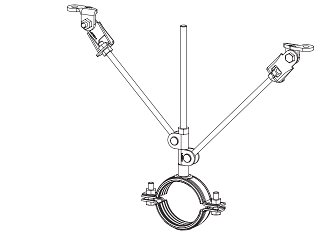
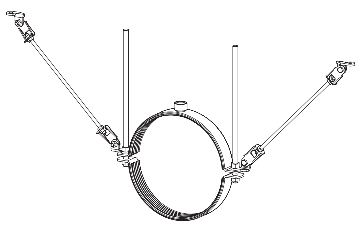
MV-P pipe rings



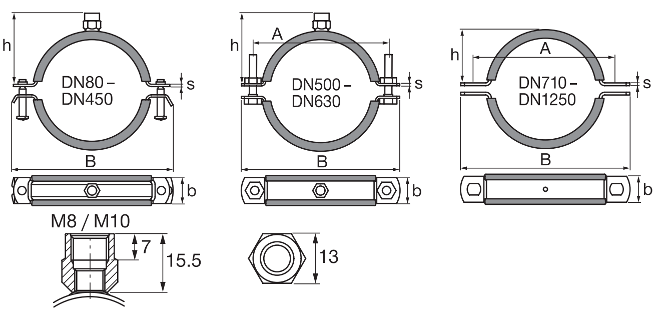
Trade attachments
Ventilation air ducts (with insulation)

MQS
Seismic System

Recommendations on type of application and type of ventilation pipe ring for the correct transfer of horizontal seismic loads, according to typicals in Chapter 3

Application		Circular air duct (with sound insulation) Dimension	Pipe ring
Single rod hanging – seismic bracing installed on vertical rod		⌀ < DN 500	MV-PI
Single rod hanging – seismic bracing installed on pipe ring flanges		DN 500 ≤ ⌀ ≤ DN 630	MV-PI
Double rod hanging – seismic bracing installed on pipe ring flanges		⌀ > DN 630	MV-PI

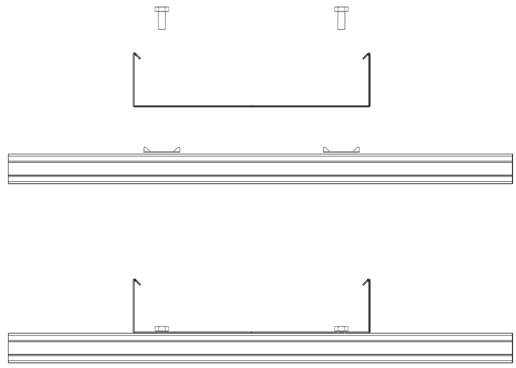
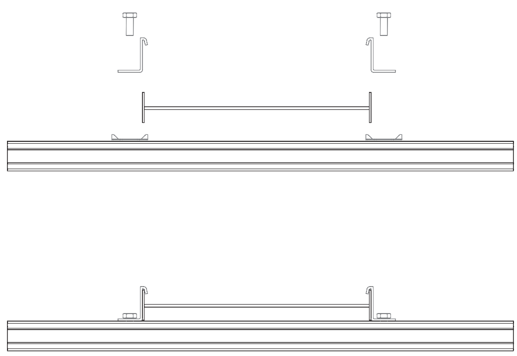
MV-PI pipe rings



Trade attachments
Cable trays

MQS Seismic System

Recommendations on type of application and type of attachment for the correct transfer of horizontal seismic loads, according to typicals in Chapter 3

Application	Fastening	
Cable tray	**Channel accessory**	**Cable tray accessory**
	Wing nut MQM – according given bolts	Bolt – according specification of cable tray manufacturer
Cable ladder	**Channel accessory**	**Cable ladder accessory**
	Wing nut MQM – according given bolts	Clip – according specification of cable ladder manufacturer

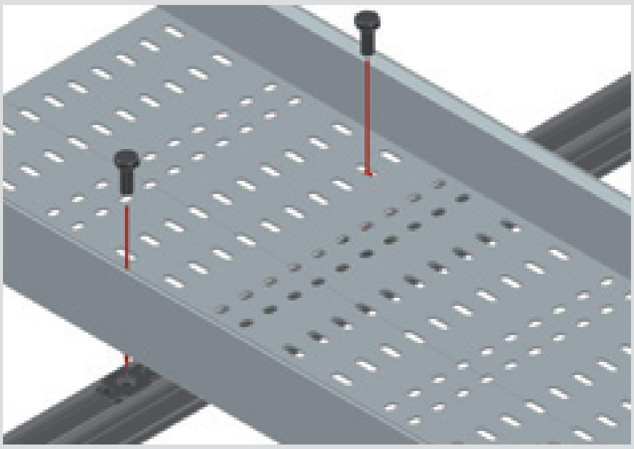


Fig. D.1 – direct fixation using cable tray holes

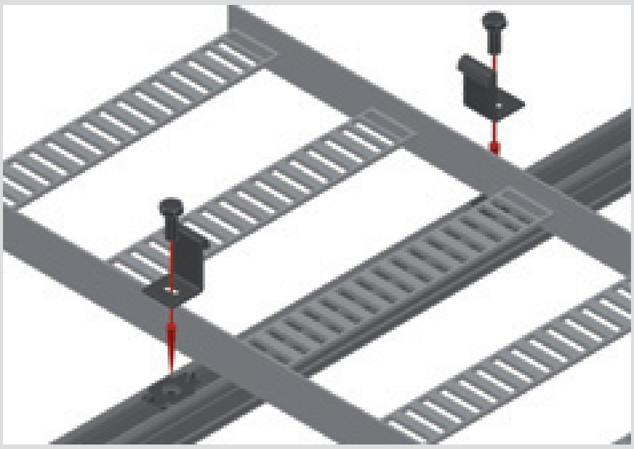
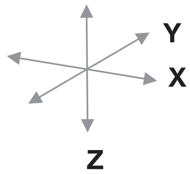
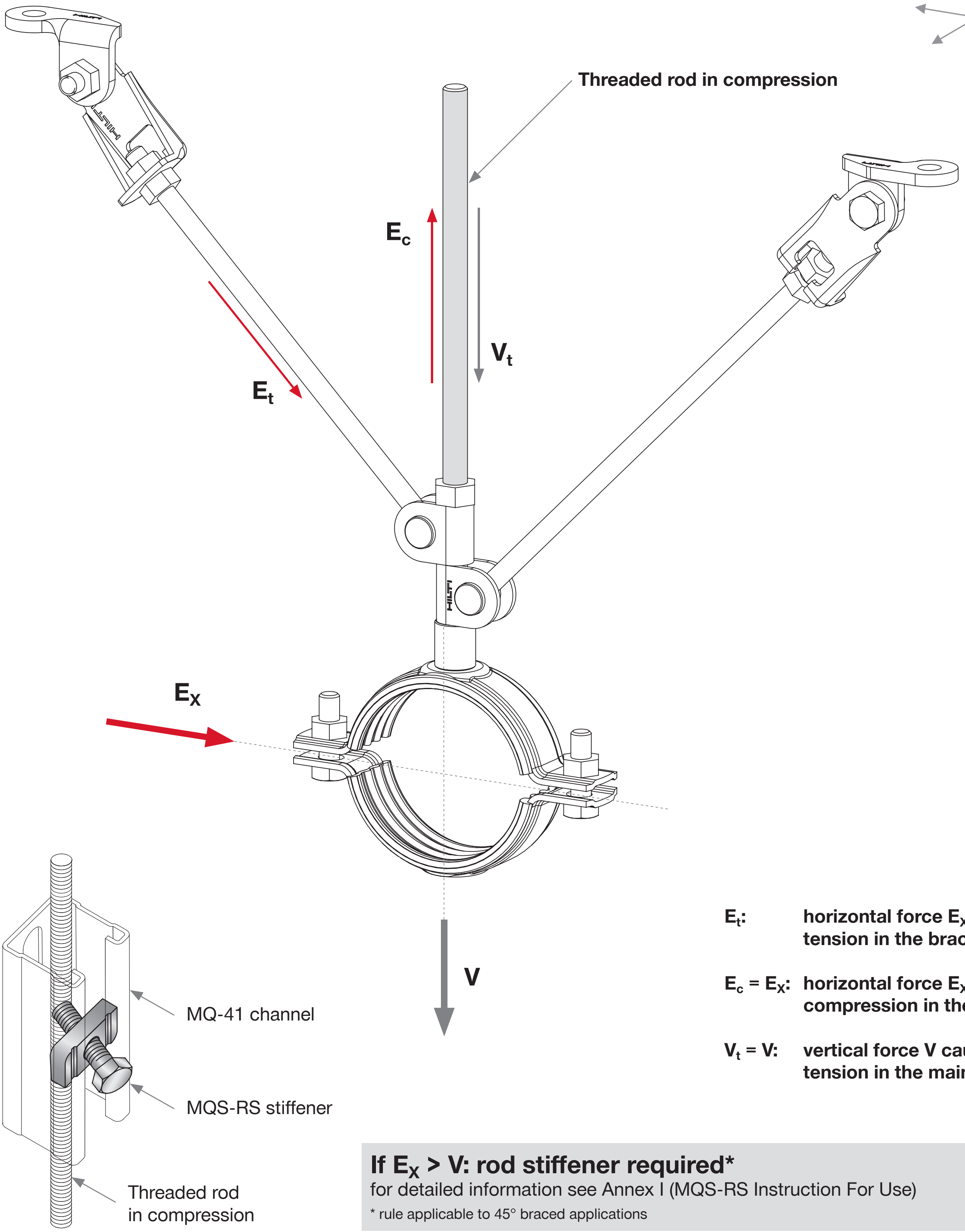


Fig. D.2 – cable ladder fixation with clips

Use of Rod Stiffener

MQS Seismic System





E_t: horizontal force E_X causes tension in the bracing

$E_c = E_X$: horizontal force E_X causes compression in the main rod

$V_t = V$: vertical force V causes tension in the main rod

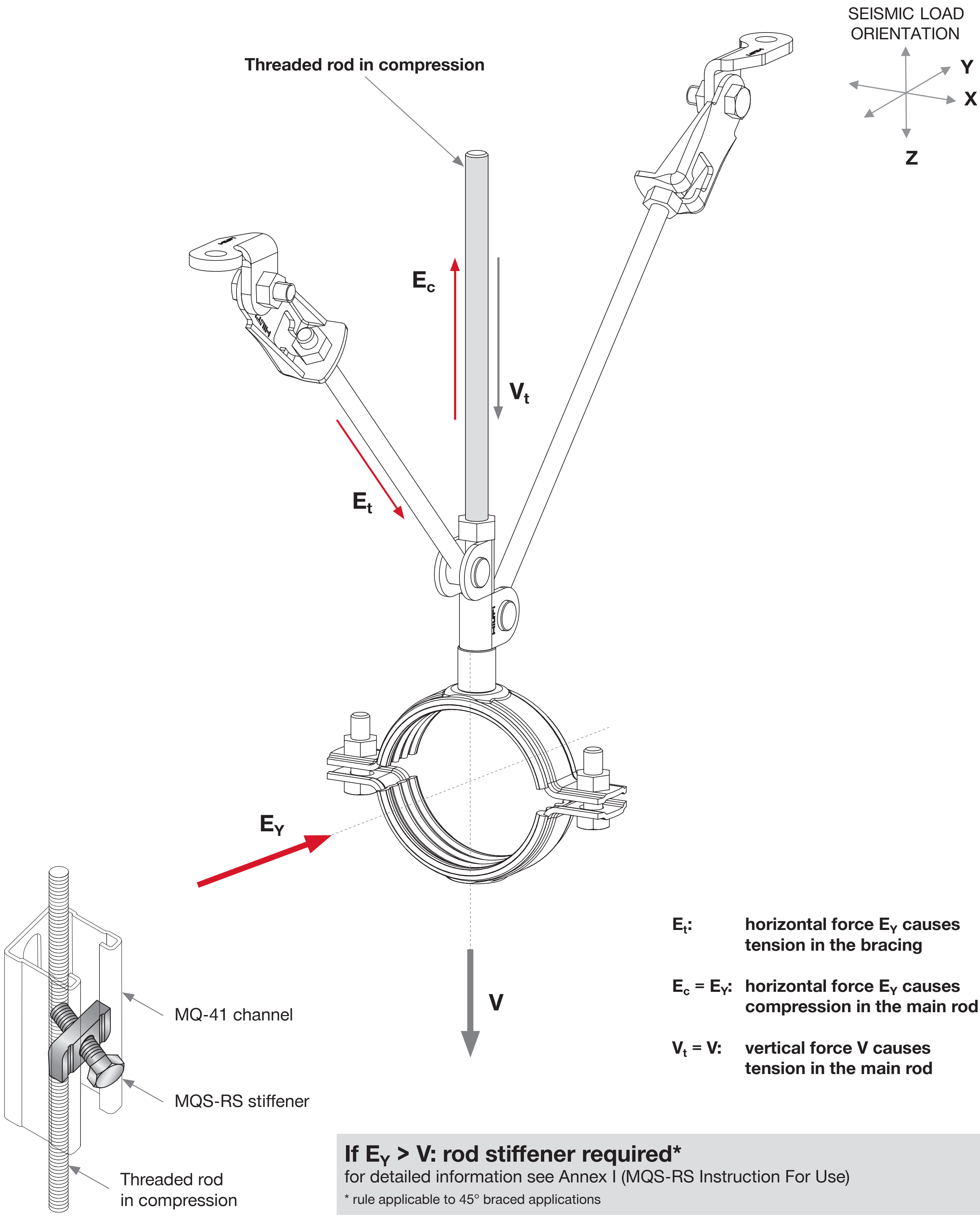
If E_X > V: rod stiffener required*

for detailed information see Annex I (MQS-RS Instruction For Use)

* rule applicable to 45° braced applications

Use of Rod Stiffener

MQS
Seismic System



E_t: horizontal force E_Y causes tension in the bracing

$E_c = E_Y$: horizontal force E_Y causes compression in the main rod

$V_t = V$: vertical force V causes tension in the main rod

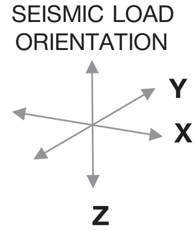
If E_Y > V: rod stiffener required*

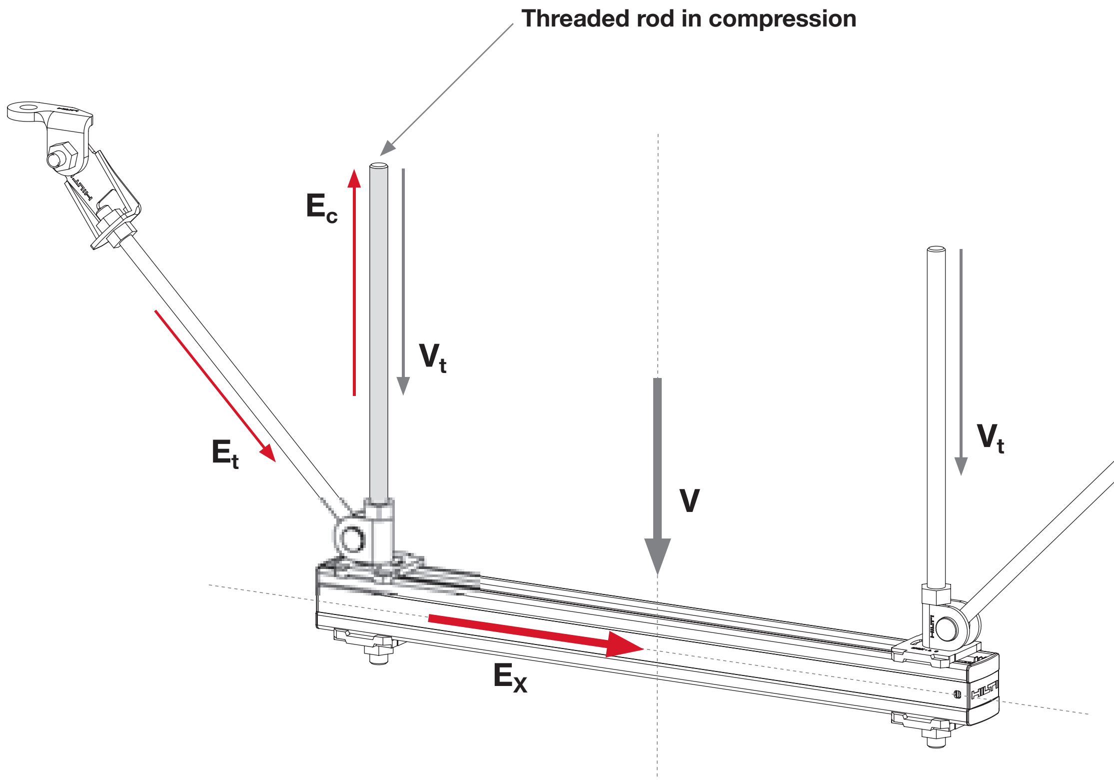
for detailed information see Annex I (MQS-RS Instruction For Use)

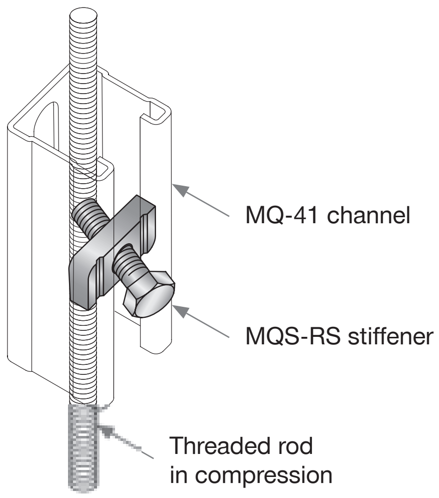
* rule applicable to 45° braced applications

Use of Rod Stiffener

MQS Seismic System







E_t: horizontal force E_X causes tension in the bracing

$E_c = E_X$: horizontal force E_X causes compression in the main rod

$V_t = V/2$: vertical force V causes tension in the main rod

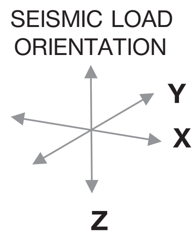
If $E_X > V/2$: rod stiffener required*

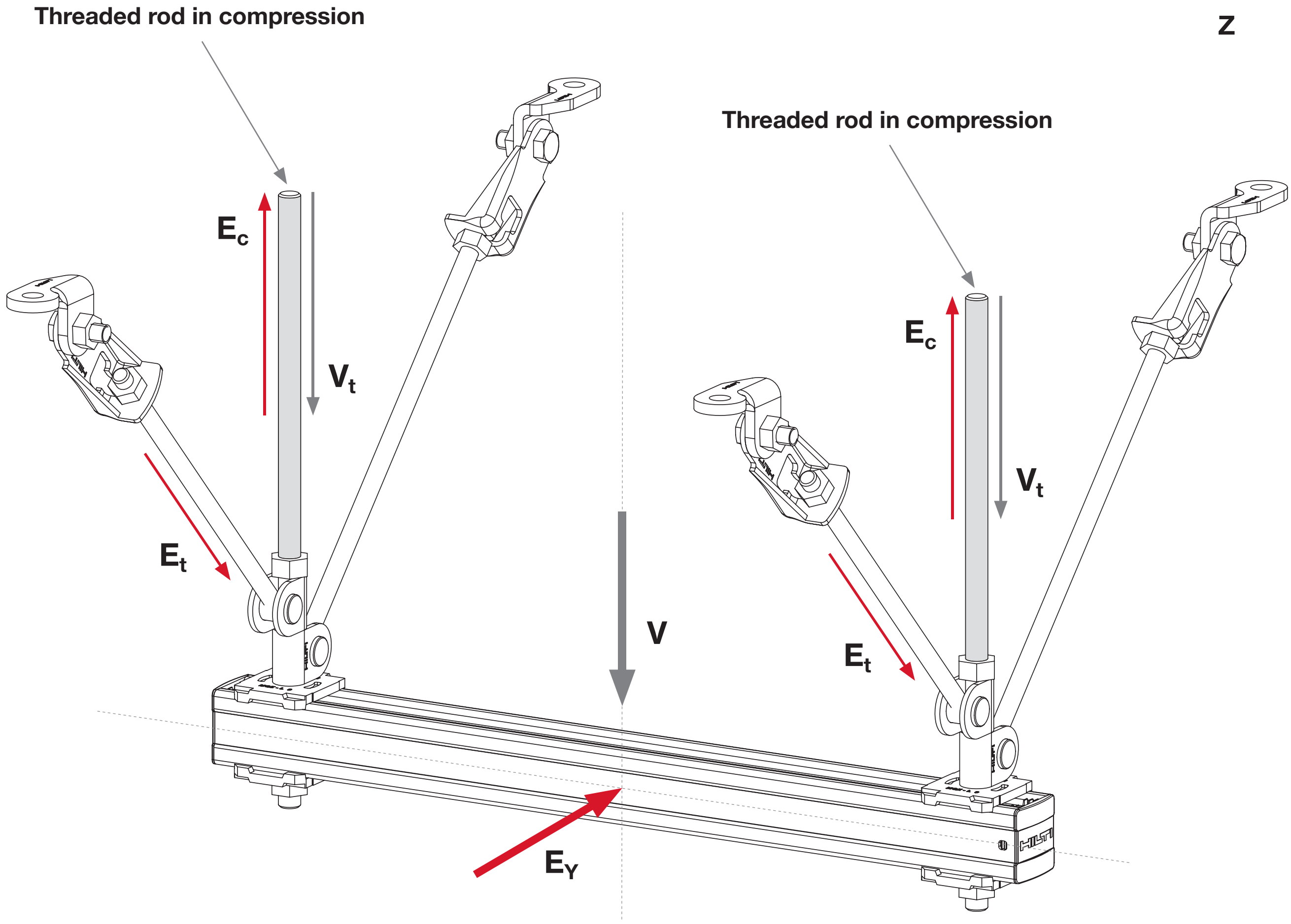
for detailed information see Annex I (MQS-RS Instruction For Use)

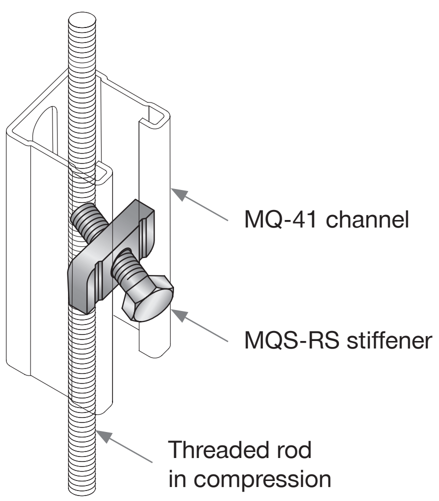
* rule applicable to 45° braced applications

Use of Rod Stiffener

MQS Seismic System







E_t:	**horizontal force E_Y causes tension in the bracing**
$E_c = E_Y/2$:	**horizontal force E_Y causes compression in the main rod**
$V_t = V/2$:	**vertical force V causes tension in the main rod**

If E_Y > V: rod stiffener required*

for detailed information see Annex I (MQS-RS Instruction For Use)

* rule applicable to 45° braced applications

Modal frequencies on non-structural elements

MQS Seismic System

Extract out of: EN 1998-1:2004

$$S_a = \alpha \cdot S \cdot \left[\left(\frac{3 \cdot (1 + Z/H)}{1 + (1 - T_a/T_1)^2} \right) - 0.5 \right]$$

where:

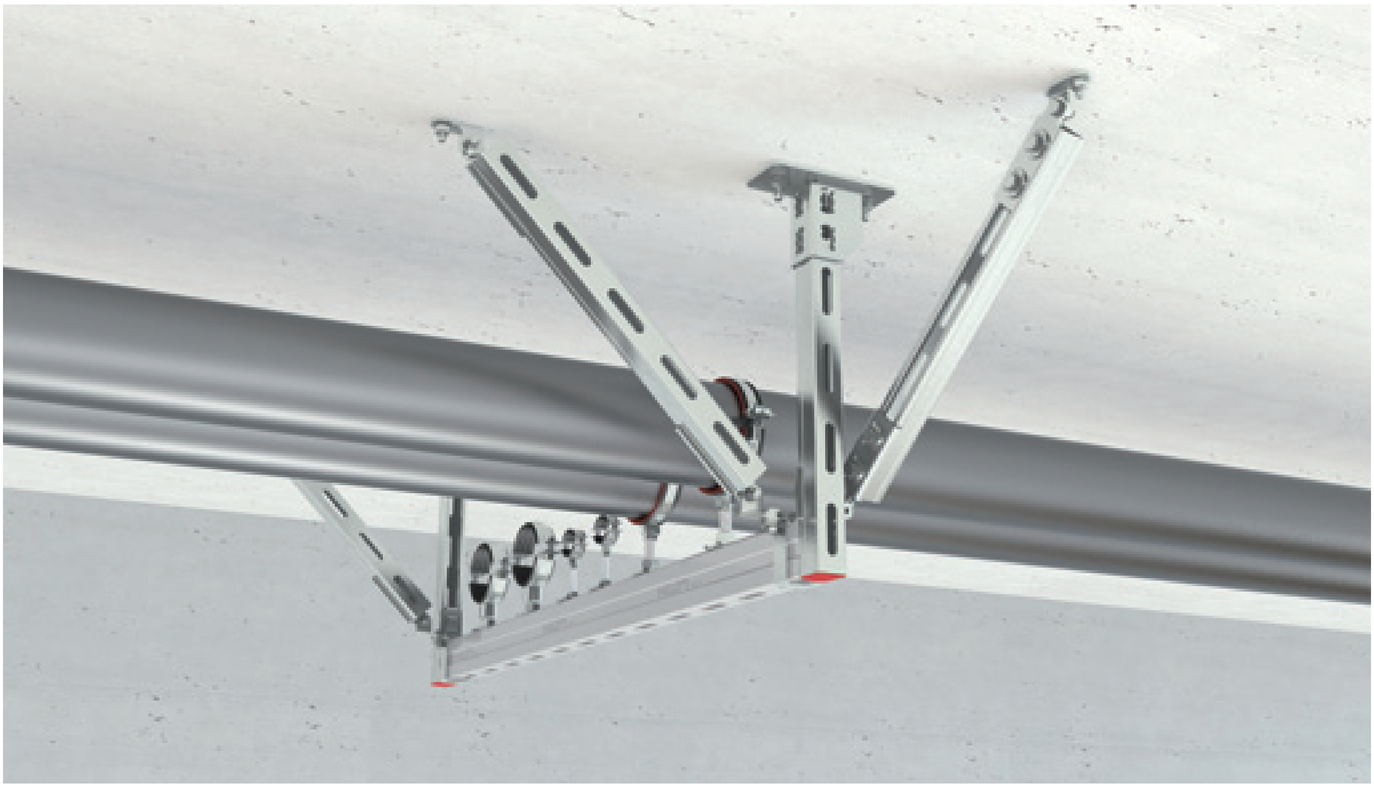
T_a	fundamental vibration period of the non-structural element	[s]
T_1	fundamental vibration period of the building in the direction concerned	[s]

T_a/T_1 optimization

Building structures normally shows comparatively small fundamental frequencies. Especially for high and/or less stiff buildings values smaller then 1Hz (fundamental vibration period $\mathbf{T_1}$ > 1s) are decisive.[1)]
Non structural elements like equipment and machines, in particular comparatively small and light components, are compared to building structures much more stiffer and shows fundamental frequencies of more then 10Hz. The danger of resonance and/or an amplification of the static substitute load is not anymore decisive. To determine the modal characteristics (natural frequencies and mode shapes), impact hammer tests were conducted on the installed field systems.

The ratio T_a/T_1 in that case is very small and it is tolerable to set it zero ($T_a/T_1 \cong 0$) to determine the static substitute load.[2)]

Fig. F.1 – Trapeze support with channels



(1): Report BBS Engineers – 1013.1 (2010) / Simplified Rayleigh Method (Prof. Dr. Alessandro Dazio and Dr. Thomas Wenk)
(2): Department of Structural Engineering University of California, San Diego, report N°: SSRP–2013/16

Modal frequencies on non-structural elements

MQS Seismic System

The following figure (Fig. F.2) show the modal frequencies of the supporting structure for installation systems, considering a most common trapeze support made out of channels (Fig. F.1).

The calculations are based on numerical models and experimental tests applied to structures built with modular channel systems.

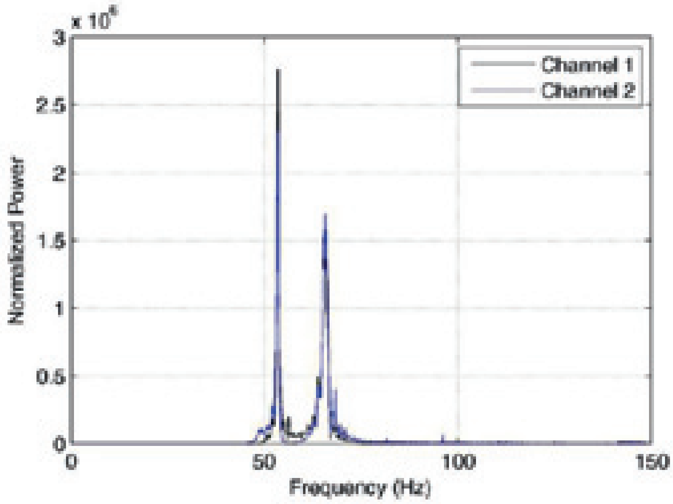


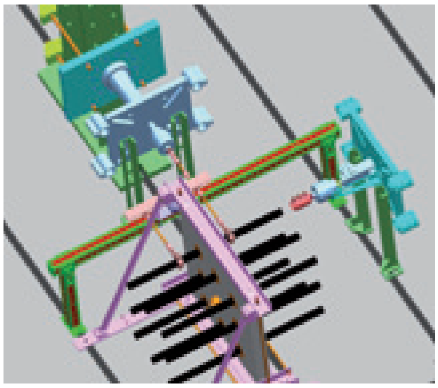
Fig. F.2 – Example transfer function for identifying the modal frequencies.

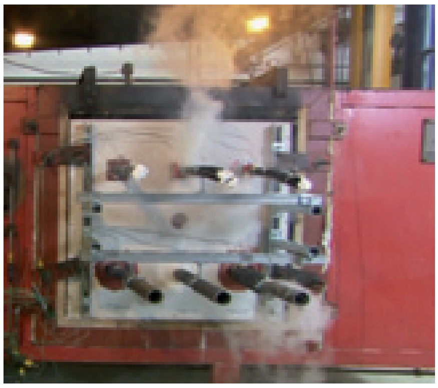
Table F.3 – Modal characterization of the single trapeze (subsystem) with rigid joints.

Model	Mode	Identified Mode	Frequency (Hz)	Period (s)
LB: Longitudinally Braced	1	Transverse	152.2	0.0066
	2	Longitudinal	453.6	0.0022
LB: Transversely Braced	1	Longitudinal	82.9	0.0121
	2	Torsion	280.7	0.0036

Behaviour of firestop penetration seals under seismic actions

Guiding Principles





The damage of non-structural components represents a key risk of post-earthquake impacts. The proper functioning of passive, as well as active, fire protection systems during fire following an earthquake can help reduce the risk to people and property.

The right Firestop reduces the extensive need for maintenance, repair and reinspection.

Seismic and fire resistance tests conducted by Hilti clearly showed the following results:

- different Firestop systems have varied ability to resist deformation without damage
- pre-engineered products were, in general, more tolerant to deformation than bulk sealants
- firestop products with a high intumescent performance are better than normal not expanding materials as gaps which appear during the movement will be closed in a fire; however, the smoke rating was in some cases significantly reduced
- The use of bracing of penetrants (pipe systems, cabling), is highly recommended to limit the absolute movement of the penetrants.

Seismic tests of penetration seals

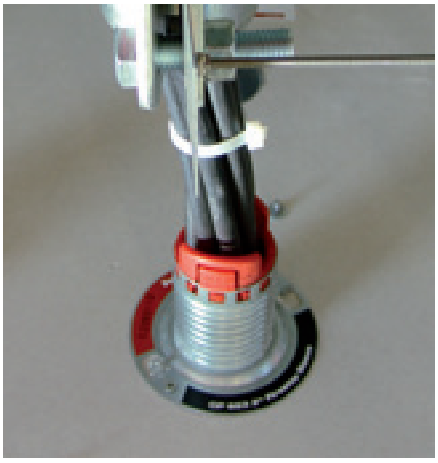
The results of internal tests show big differences in the behaviour, appearance and failure modes of different Firestop product systems. These results were verified in a large scale seismic shake table test at University of California, San Diego.

- Quasi- static cyclic loads according to FEMA* 461 protocol applied directly on one single penetrant, whereas the wall was fixed
- The use of stiff and unflexible materials with low elasticity (e.g. mortars and grouts, board systems, semi-plastic sealants) may be critical especially in connection with pipes or cable trays where displacement forces are high
- Metal pipes may be deformed, plastic pipes may be bent during movement. A low flexibility of the Firestop system will not be able to make up for the penetrant movement. Penetrants or walls might break or even be destroyed. With the consequence of a lower or non-existing smoke tightness or fire integrity
- The subsequent fire tests confirmed the seismic results. Damaged, stiff and hard board systems did not pass the fire tests. Flexible Firestop systems or pre-engineered devices passed the tests and achieved the desired fire integrity due to limited damage during a seismic event. High performance intumescent products clearly add an additional safety level to the compartimentation of a building

* Federal Emergency Management Agency: Code for Interim testing protocol for determining the seismic performance characteristics of structural and non-structural components

Hilti Firestop Sleeve CFS-SL

Seismic performance test sheet



Product description: Hilti firestop sleeve is a pre-engineered device used for firestop seals in small openings, offering 2” and 4” dimensions diameter for high traffic cable penetrations with an easy repenetration of cables.

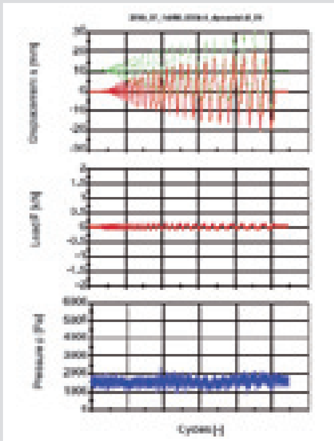
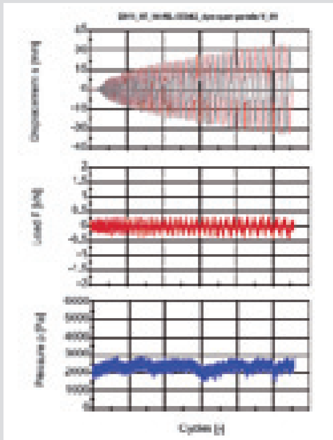
Tested application: cable bundle.

Test setup / description: Simulated seismic firestop tests conducted in the Hilti research laboratory, accredited by the DAP (German Accreditation System for Testing) regarding the standard DIN EN ISO / IEC 17025. The quasi-static cyclic loads according to FEMA 461* protocol were applied directly on one single penetrant, whereas the wall was fixed.

* Federal Emergency Management Agency: code for interim testing protocol for determining the seismic performance characteristics of structural and non-structural components

Test results

Test configuration: cable penetration to represent the key application. Firestop sleeve tested in typical opening size. Installation in a drywall.

Results:	**x-direction**	**y-direction**	**zz-direction**
1. Displacement amplitude 2. Movement force 3. Pressure			Not tested as rotation in flexible material is comparable to x- and y-direction
Movement	± 20 mm	± 32 mm	
Resistance to movement	Low (<1kN)	Low (<1kN)	
Initial pressure	1500 Pa	2500 Pa	
Pressure drop	No	No	
Airtight during test	Yes	Yes	
Firestop functionality	Passed	Passed	

Summary and interpretation of results

- No cracks or deformations were observed during movement of the penetrating cables
- The high stability of the firestop sleeve at the outside and the flexible membrane in the inside of the device allowed a maximum of movement of the cables
- No deformation of penetrating items
- The air- and gas-tightness was fully maintained during the whole test
- In the subsequent orientation fire test the firestop sleeve successfully kept smoke-tightness and ensured the fire integrity of the penetration

For specific application details the national approvals or the European Technical Approval must be observed. All results are based upon the test constellation and its respective parameters described in the Hilti seismic firestop test reports and the application details set out in the Hilti installation instructions.

Hilti Firestop Collar CFS-C, CFC-P
Seismic performance test sheet

Product description: Hilti firestop collar used for firestop seals of plastic pipe penetrations in walls and floors.

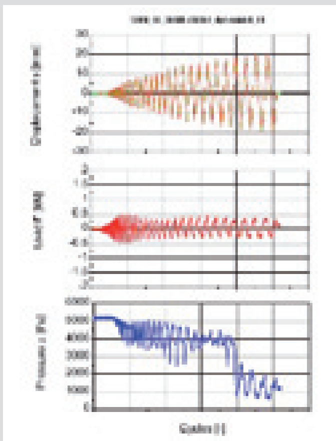
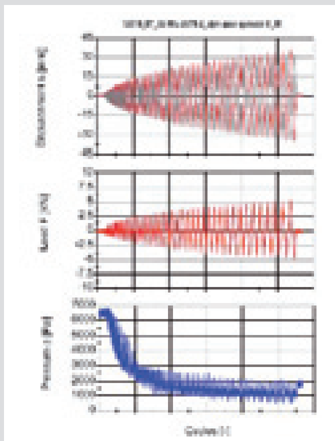
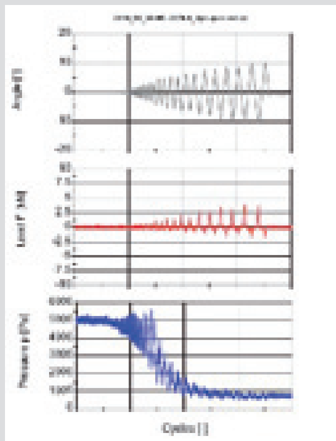
Tested application: plastic pipe penetration.

Test setup / description: Simulated seismic firestop tests conducted in the Hilti research laboratory, accredited by the DAP (German Accreditation System for Testing) regarding the standard DIN EN ISO / IEC 17025. The quasi-static cyclic loads according to the FEMA 461* protocol were applied directly on one single penetrant, whereas the wall was fixed.

* Federal Emergency Management Agency: code for interim testing protocol for determining the seismic performance characteristics of structural and non-structural components

Test results

Test configuration: cable penetration to represent the key application. Firestop sleeve tested in typical opening size. Installation in a drywall.

Results:	**x-direction**	**y-direction**	**zz-direction**
1. Displacement amplitude 2. Movement force 3. Pressure			
Movement	± 20 mm	± 32 mm	± 10°
Resistance to movement	Low (<1kN)	Medium (<5kN)	Medium (<5kN)
Initial pressure	5000 Pa	6000 Pa	5000 Pa
Pressure drop**	Low-to-medium	Low-to-high	Medium-to-high Pronounced plateau
Airtight during test**	Yes / Partly	Yes / No	Yes / No
Firestop functionality	Passed	Passed	Passed

** Performance data influenced by smoke seal system.

Summary and interpretation of results

- No cracks or deformations were observed during movement of the pipes
- The collar was still fixed to the wall and fully intact
- High intumescent performance of the collar ensured fire integrity of the penetration
- The sealant, functioning as a smoke seal in the annular gap, is the critical component. The usage of an equivalent smoke seal product (such as Hilti firestop acrylic sealant CP606 / CFS-S ACR) is recommended

For specific application details the national approvals or the European Technical Approval must be observed. All results are based upon the test constellation and its respective parameters described in the Hilti seismic firestop test reports and the application details set out in the Hilti installation instructions.

Hilti Firestop Acrylic Sealant CFS-S ACR
Seismic performance test sheet

Product description: Hilti firestop acrylic sealant used for firestop seals of metal pipe penetrations and various other applications together with other Hilti firestop systems as a gap filler or smoke seal in walls and floors.

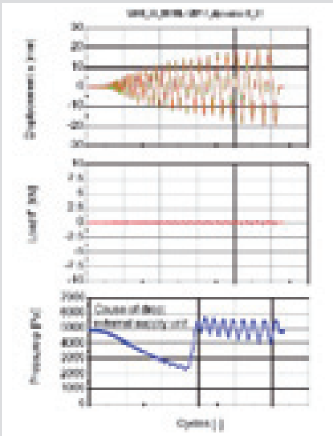
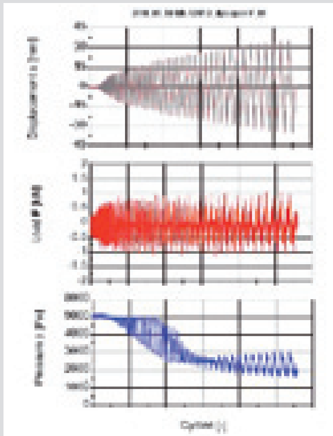
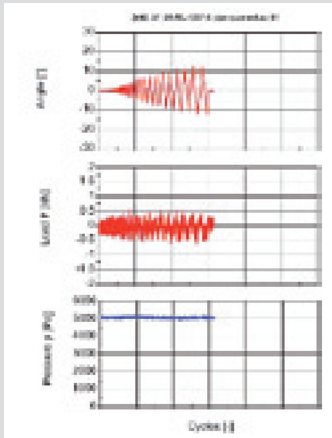
Tested application: pipe penetration.

Test setup / description: Simulated seismic firestop tests conducted in the Hilti research laboratory, accredited by the DAP (German Accreditation System for Testing) regarding the standard DIN EN ISO / IEC 17025. The quasi-static cyclic loads according to the FEMA 461* protocol were applied directly on one single penetrant, whereas the wall was fixed.

* Federal Emergency Management Agency: code for interim testing protocol for determining the seismic performance characteristics of structural and non-structural components

Test results

Test configuration: cable penetration to represent the key application. Firestop sleeve tested in typical opening size. Installation in a drywall.

Results:	**x-direction**	**y-direction**	**zz-direction**
1. Displacement amplitude 2. Movement force 3. Pressure			
Movement	± 20 mm	± 30 mm	± 10°
Resistance to movement	Low (<1kN)	Low (<1kN)	Low (<1kN)
Initial pressure	5000 Pa	5000 Pa	5000 Pa
Pressure drop	No (drop in chart caused by external supply unit)	Medium, Pronounced plateau	No
Airtight during test	Partly (yes)	Partly	Yes
Firestop functionality	No rated due to non-insulated metal pipe		

Summary and interpretation of results

- No cracks or deformations were observed during movement of the pipe in x- and zz-directions. During movement in y-direction, one crack at the edge of the drywall occurred. The air- and gas-tightness was maintained during a long period of the test.
- The high flexibility of the sealant followed most of the movement of the penetrants
- The sealant showed excellent elastic behavior and very good adhesion to penetrants, no deformation
- In the subsequent orientation fire test the firestop acrylic sealant was not able to fully keep smoke-tightness and to ensure the fire integrity. The reason for this was the missing temperature rating due to the missing insulation of the metal pipe. With a regular mineral-wool insulated pipe, the fire integrity would have met the requirements

For specific application details the national approvals or the European Technical Approval must be observed. All results are based upon the test constellation and its respective parameters described in the Hilti seismic firestop test reports and the application details set out in the Hilti installation instructions.

Hilti Firestop Foam Hilti CFS-F FX
Seismic performance test sheet

Product description: Hilti Firestop Foam is used for permanent firestop seals in small and medium sized openings (optimum size range 100x100 to 300x300 mm) for cable, pipe and mixed penetrations.

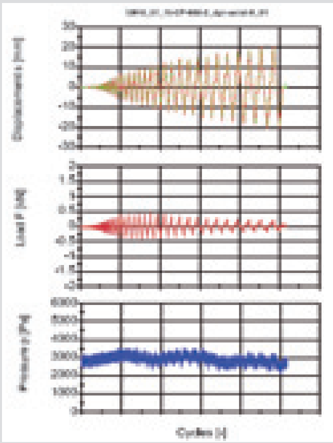
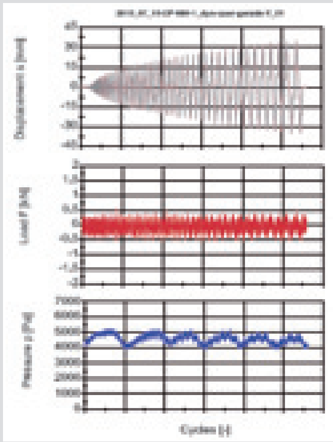
Tested application: cable bundle.

Test setup / description: Simulated seismic firestop tests conducted in the Hilti research laboratory, accredited by the DAP (German Accreditation System for Testing) regarding the standard DIN EN ISO / IEC 17025. The quasi-static cyclic loads according to the FEMA 461* protocol were applied directly on one single penetrant, whereas the wall was fixed.

* Federal Emergency Management Agency: code for interim testing protocol for determining the seismic performance characteristics of structural and non-structural components

Test results

Test configuration: cable penetration to represent the key application. Firestop sleeve tested in typical opening size. Installation in a drywall.

Results:	x-direction	y-direction	zz-direction
1. Displacement amplitude 2. Movement force 3. Pressure			Not tested as rotation in flexible material is comparable to x- and y-direction
Movement	± 20 mm	± 32 mm	
Resistance to movement	Low (<1kN) due to flexible foam	Low (<1kN) due to flexible foam	
Initial pressure	2800 Pa	4500 Pa	
Pressure drop	Low	Low	
Airtight during test	Yes	Yes	
Firestop functionality	Passed	Passed	

Summary and interpretation of results

- No cracks or deformations were observed during movement of the penetrating cables
- The high flexibility of the Firestop Foam followed the movement of the penetrants
- Slight release of foam and cables shows positive result on flexibility under large forces (product stays in opening)
- No damage or deformation of penetrating items
- The air and gas tightness was maintained during the whole test
- In the subsequent orientation fire test the intumescent Firestop Foam successfully kept smoke tightness and ensured the fire integrity of the penetration
- In the seismic compliance test no damage visible

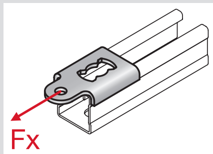
For specific application details the national approvals or the European Technical Approval must be observed. All results are based upon the test constellation and its respective parameters described in the Hilti seismic firestop test reports and the application details set out in the Hilti installation instructions.

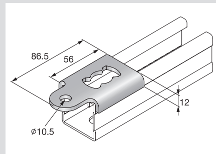
Product Data Sheet

MQS Seismic System

Order description	Desing load	
	+ F_x	- F_x
MQS-C	6.24 kN	6.24 kN

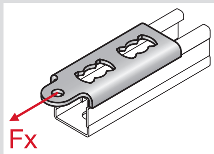
Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0.
Note: final load for a particular seismic support is depending on the set up of the used items!

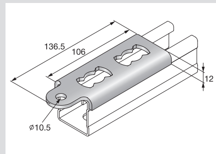




Order description	Desing load	
	+ F_x	- F_x
MQS-CD	12.48 kN	12.48 kN

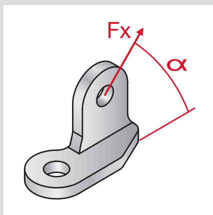
Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0.
Note: final load for a particular seismic support is depending on the set up of the used items!

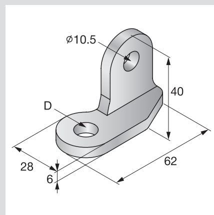




Order description	D	Desing load	
		+ F_x	- F_x
MQS-A-8	9.4 mm	11.60 kN	11.60 kN
MQS-A-10	11.5 mm		
MQS-A-12	13.6 mm		
MQS-A-16	16.3 mm		

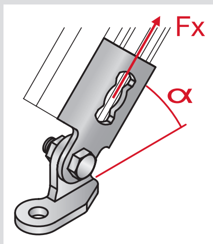
Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid for α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

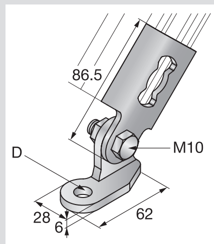




Order description	D	Desing load	
		+ F_x	- F_x
MQS-AC-10	11.5 mm	6.24 kN	6.24 kN
MQS-AC-12	13.6 mm		

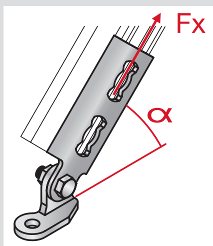
Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid for α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

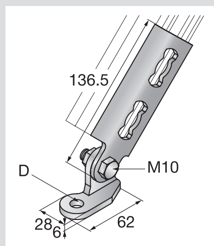




Order description	D	Desing load	
		+ F_x	- F_x
MQS-ACD-10	11.5 mm	11.60 kN	11.60 kN
MQS-ACD-12	13.6 mm		

Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid for α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

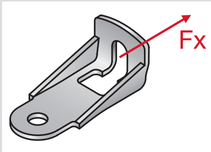


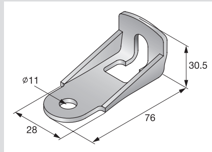


Product Data Sheet

MQS Seismic System

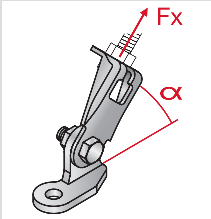
Order description	Desing load	
	$+ F_X$	$- F_X$
MQS-B	4.56 kN	n.a.

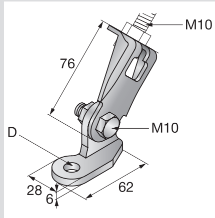




Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0.
Note: final load for a particular seismic support is depending on the set up of the used items!

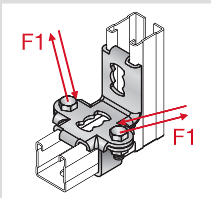
Order description	D	Desing load	
		$+ F_X$	$- F_X$
MQS-AB-8	9.4 mm	4.56 kN	n.a.
MQS-AB-10	11.5 mm		
MQS-AB-12	13.6 mm		
MQS-AB-16	16.3 mm		

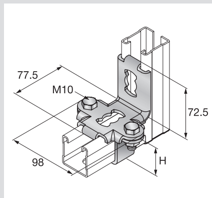




Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid for α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

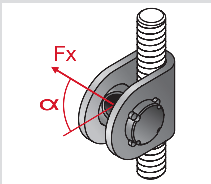
Order description	Desing load	
	$+ F_1$	$- F_1$
MQS-W-41/-72/-41D	6.10 kN	6.10 kN

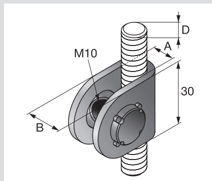




Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid for all angles.
Note: final load for a particular seismic support is depending on the set up of the used items!

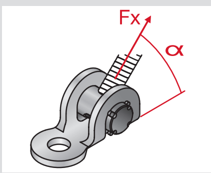
Order description	D	A	Desing load	
			$+ F_X$	$- F_X$
MQS-H-8	M8	8.3 mm	12.96 kN	n.a.
MQS-H-10	M10	10.3 mm		
MQS-H-12	M12	12.3 mm		

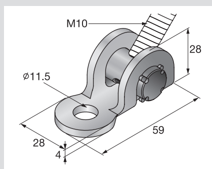




Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid f or α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

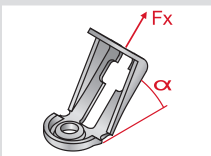
Order description	Desing load	
	$+ F_X$	$- F_X$
MQS-CH	4.67 kN	n.a.

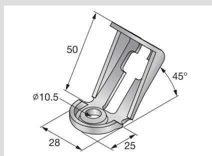




Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid f or α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

Order description	Desing load	
	$+ F_X$	$- F_X$
MQ3D-AS	4.56 kN	n.a.





Shown load values are desing values (F_{Rd}). The partial safety factor for the action is 1.0. Load values are valid f or α = 45°±15°.
Note: final load for a particular seismic support is depending on the set up of the used items!

Product development and tests

MQS Seismic System

In addition to static analysis, taking into account the above design rules (see Chapter 2) static or dynamic load tests were performed on all MQS parts.

With these results of the load tests, the supporting FEM model could be calibrated and optimized, thus, the suitability of specific applications could be demonstrated and verified.

The following figures show examples of the test setup on MQS-ACD connector (Fig. H.1) as well as the results of the FEM analysis (Fig. H.2).

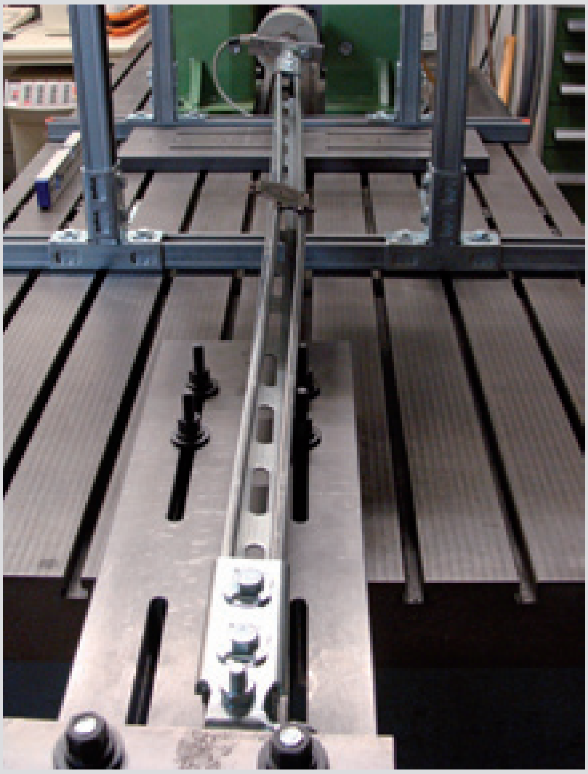


Fig. H.1 – Compression load test on MQS-ACD component with MQ-41

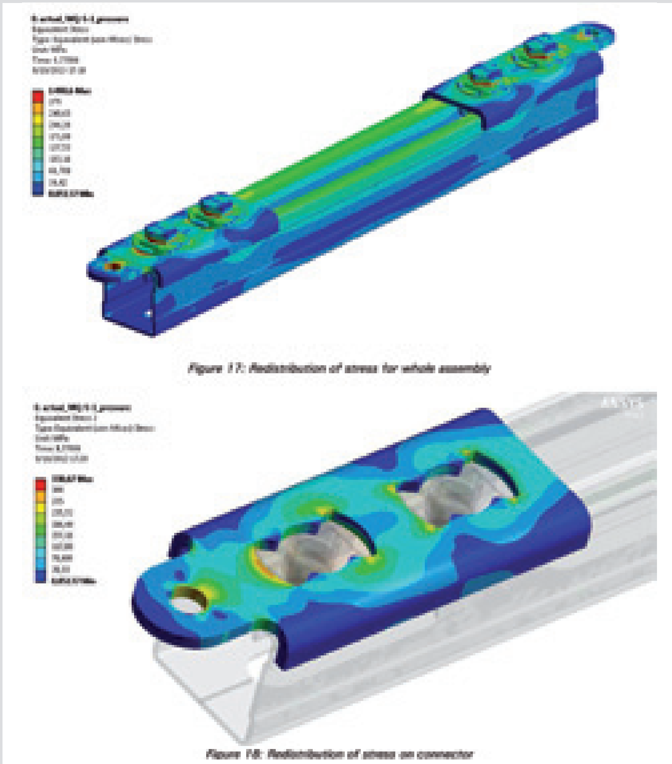
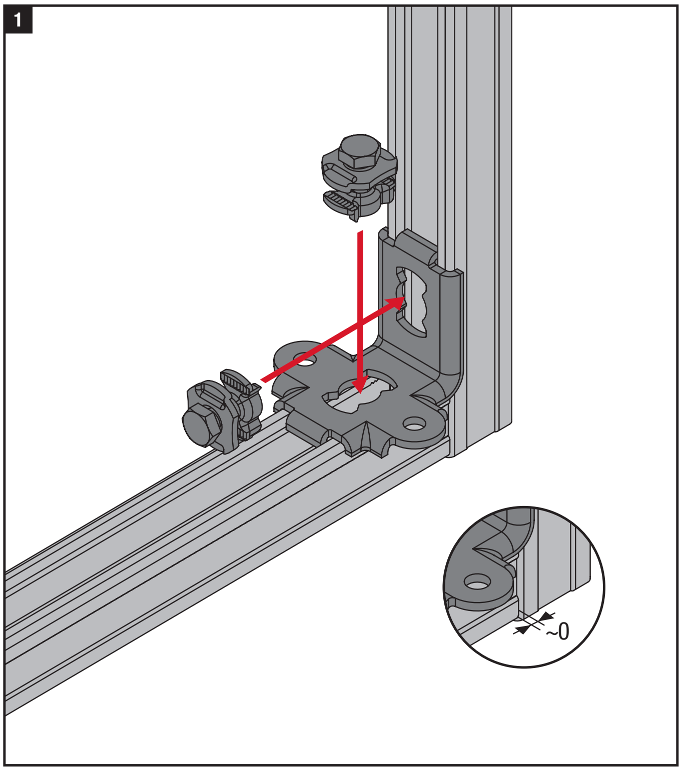
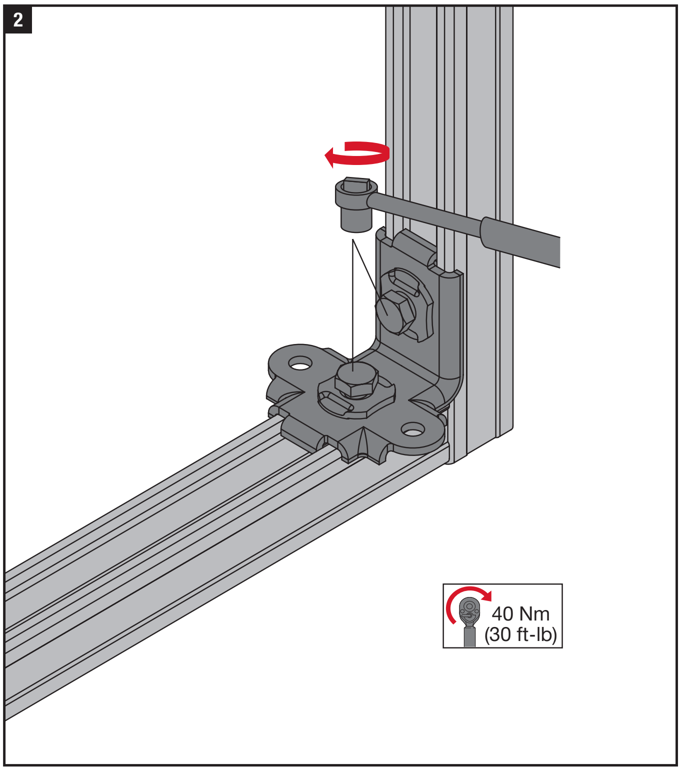


Fig. H.2 – Finite Elements Analysis on MQS-ACD component

Instruction for use MQS-W

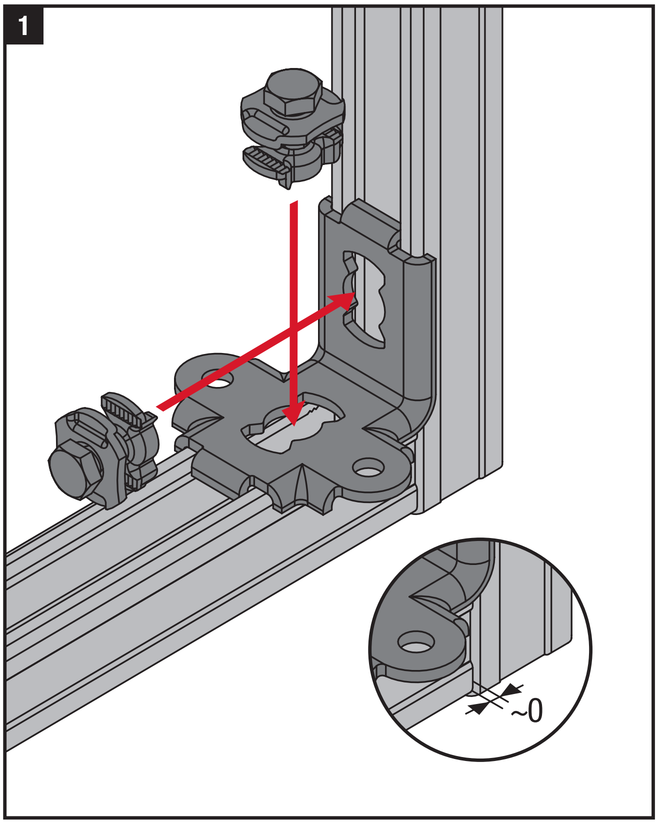
MQS Seismic System

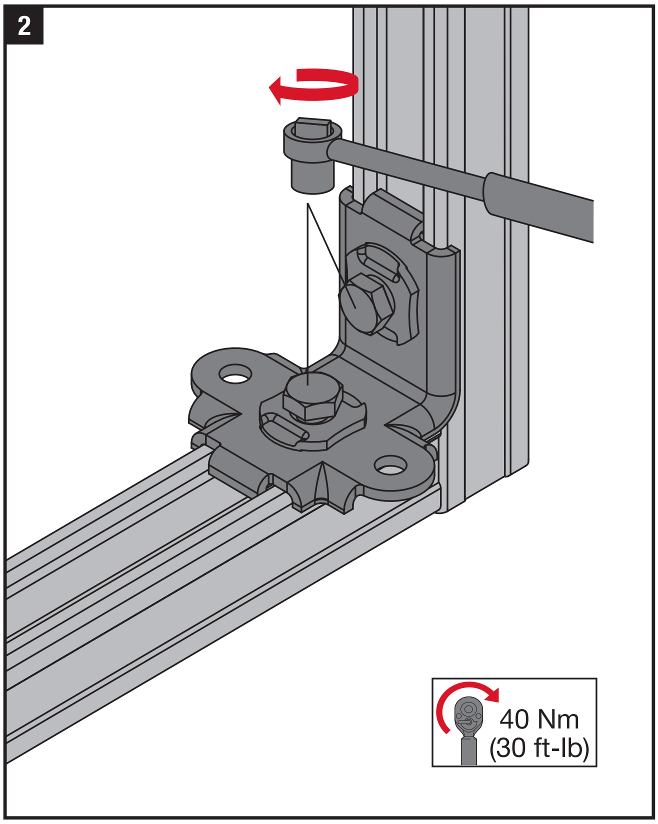


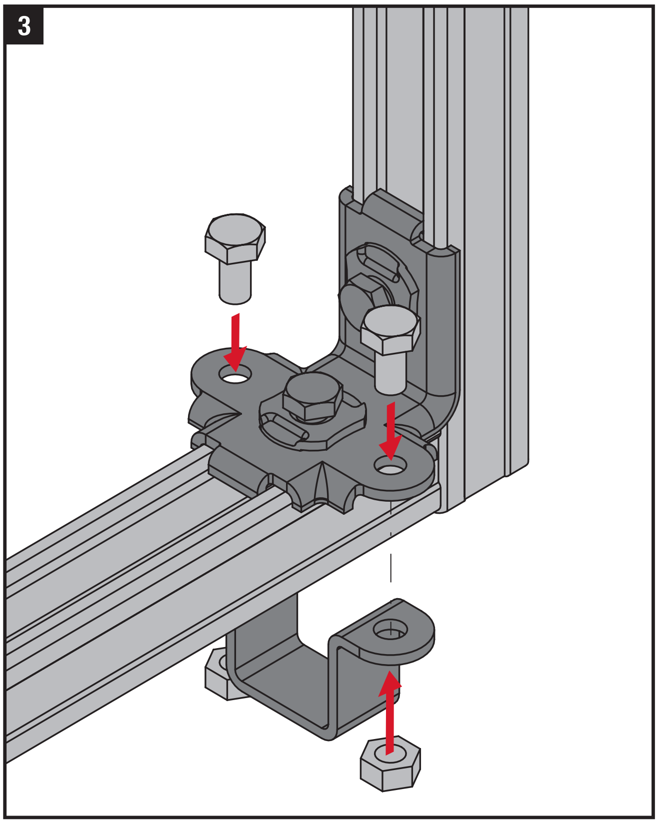


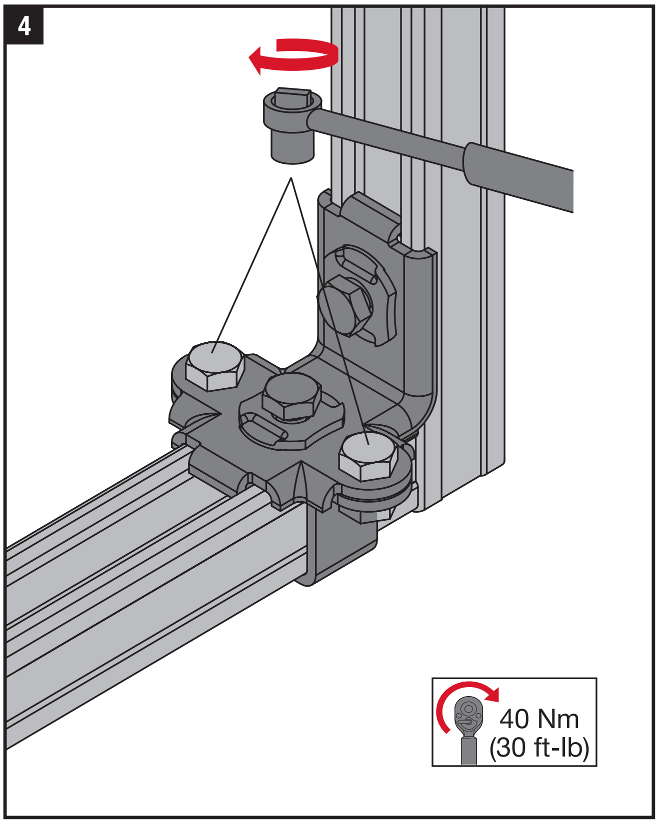
Instruction for use MQS-W Set

MQS Seismic System



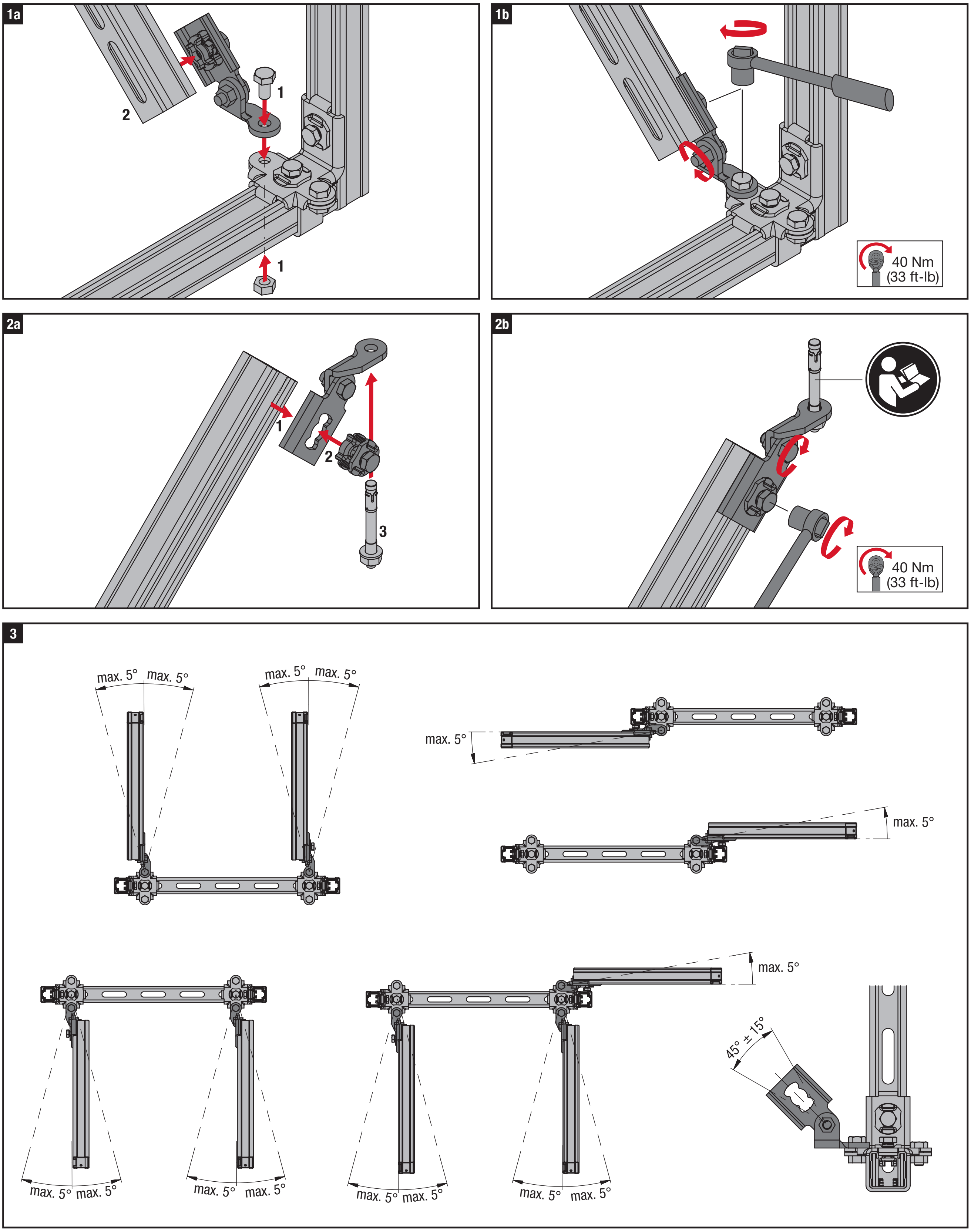






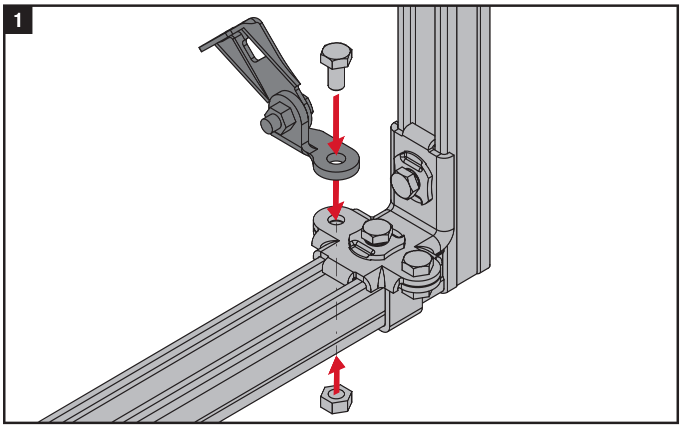
Instruction for use MQS-AC/ACD with MQS-W Set

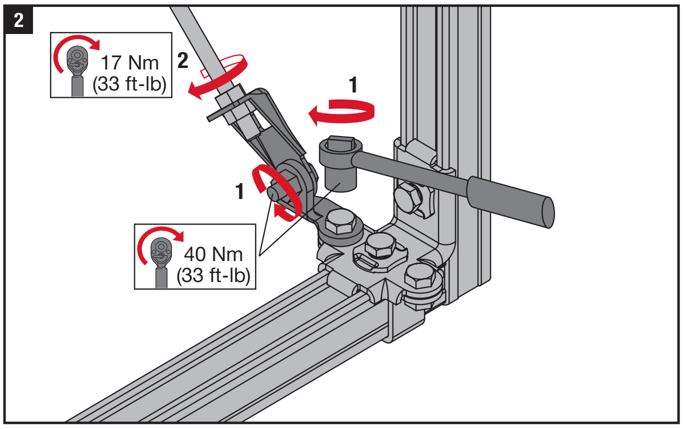
MQS Seismic System

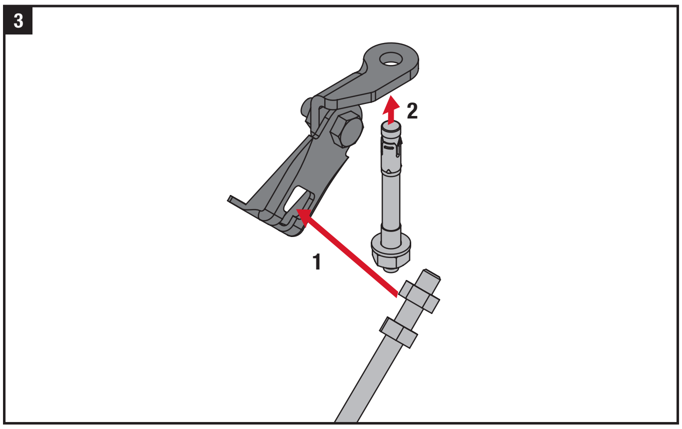


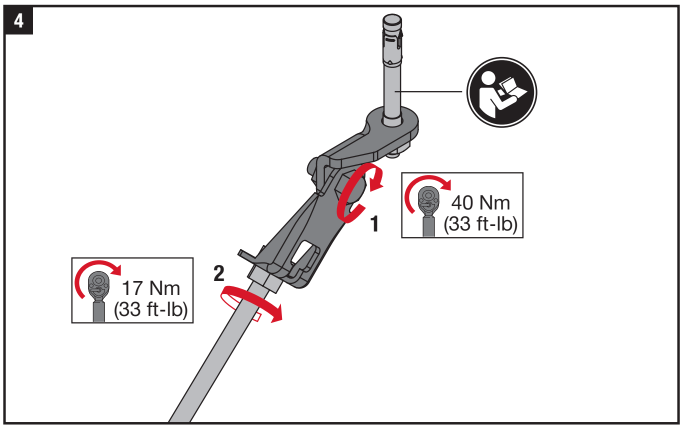
Instruction for use MQS-AB with MQS-W Set

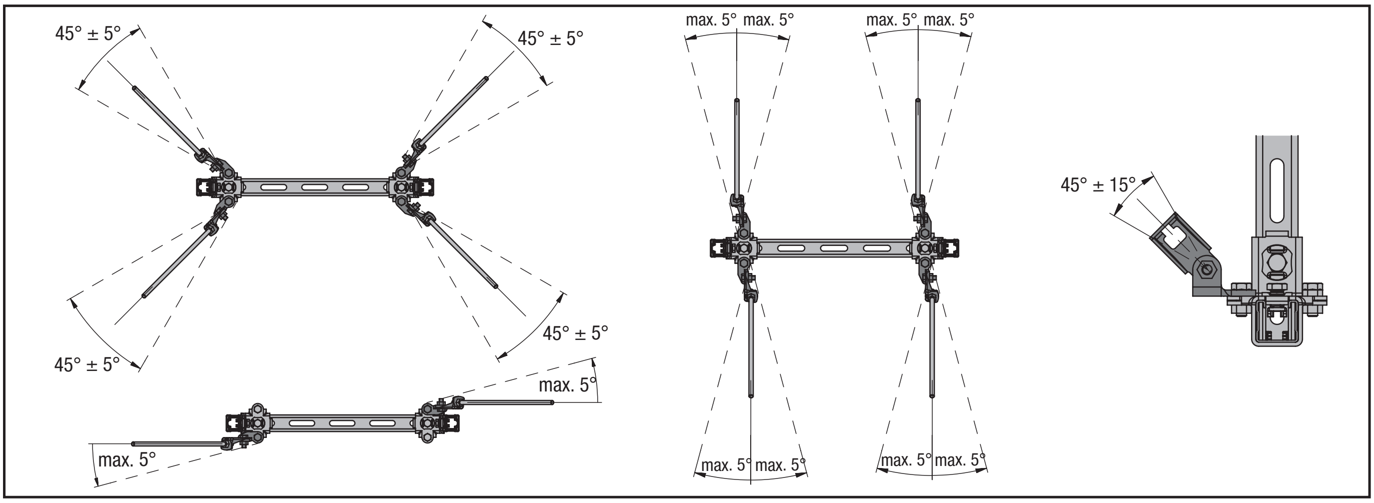
MQS Seismic System





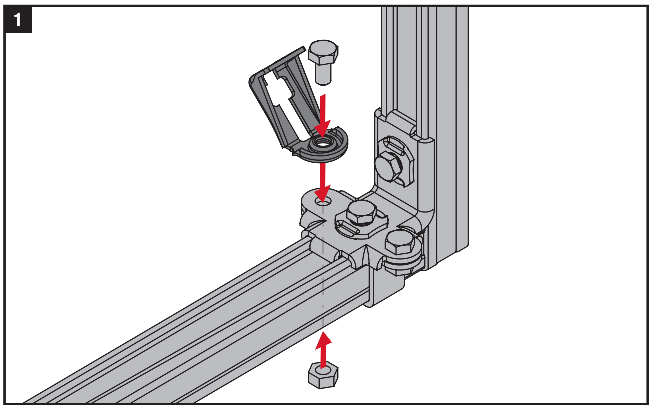


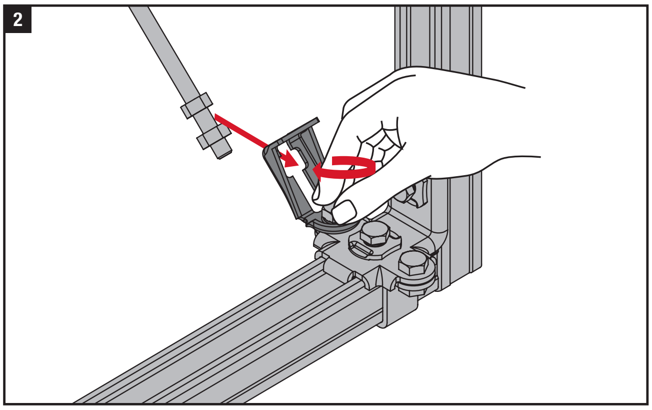


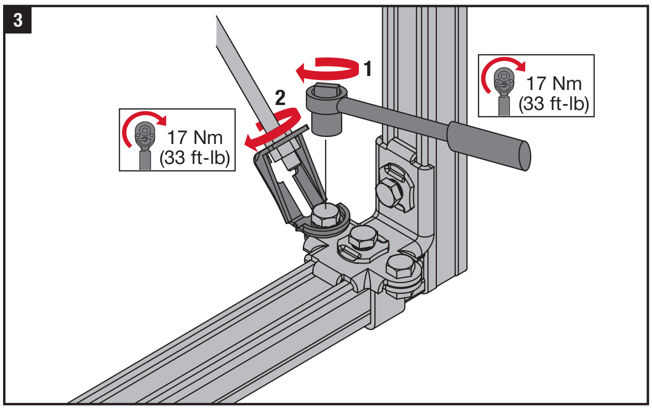


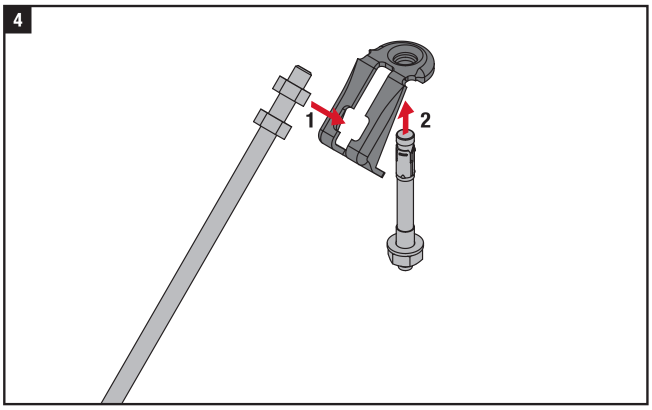
Instruction for use MQ3D-AS with MQS-W Set

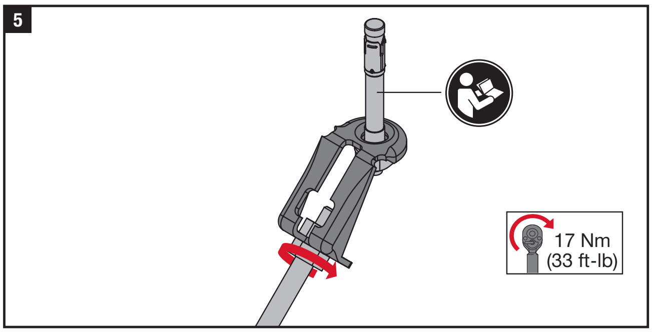
MQS Seismic System

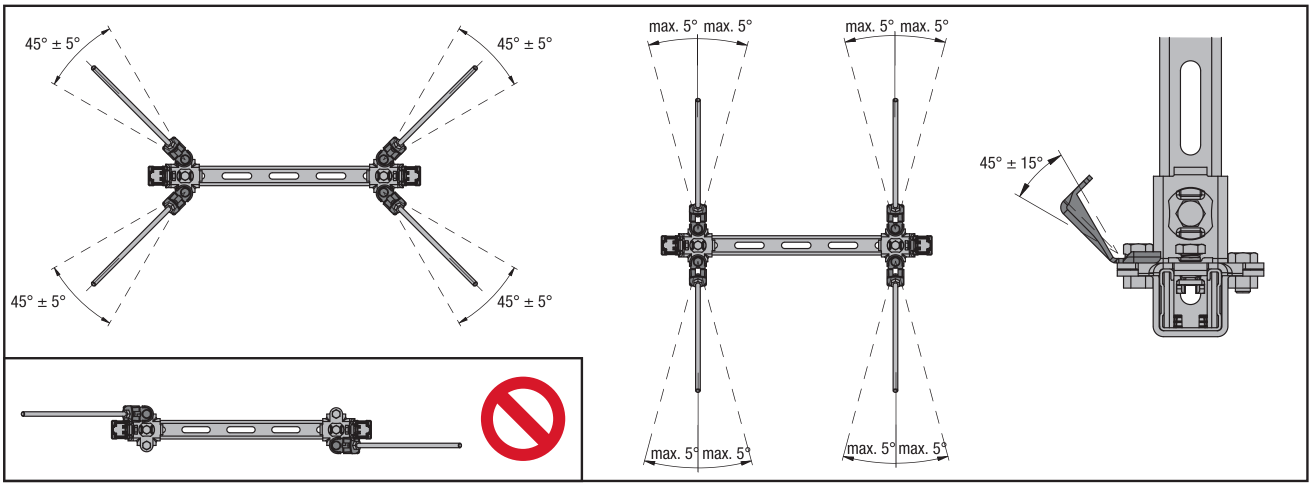






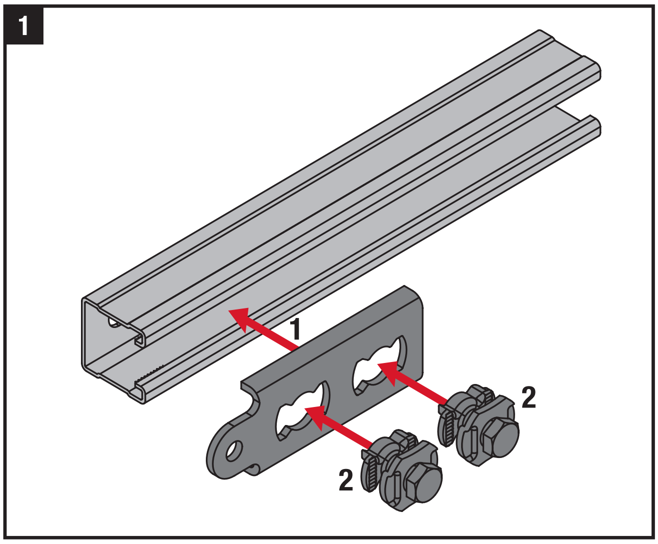


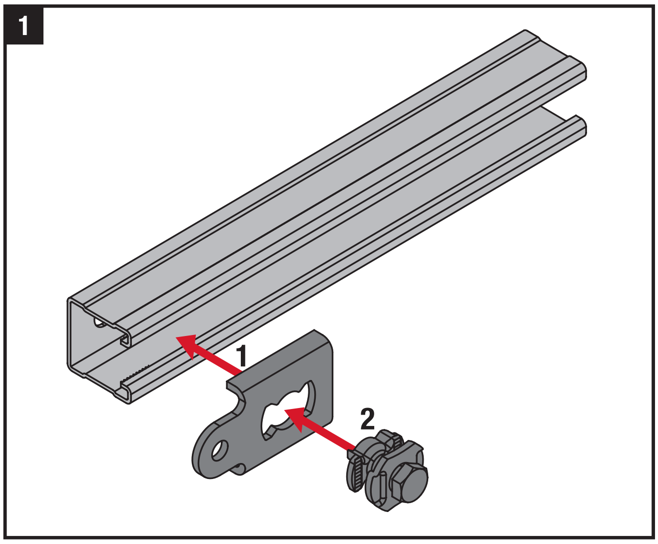


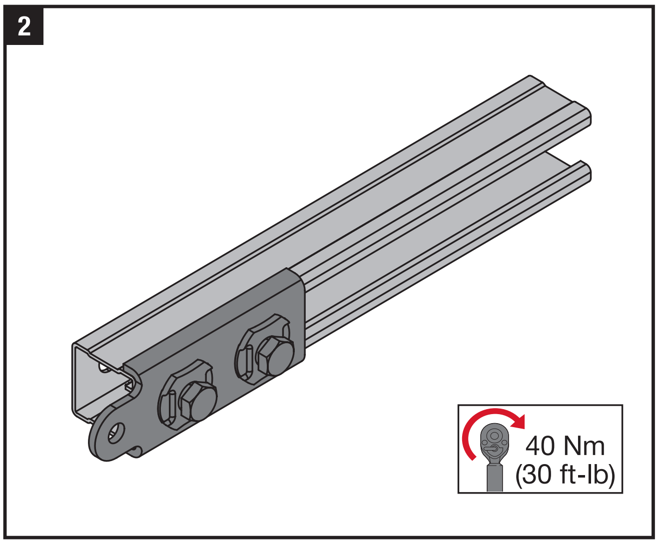


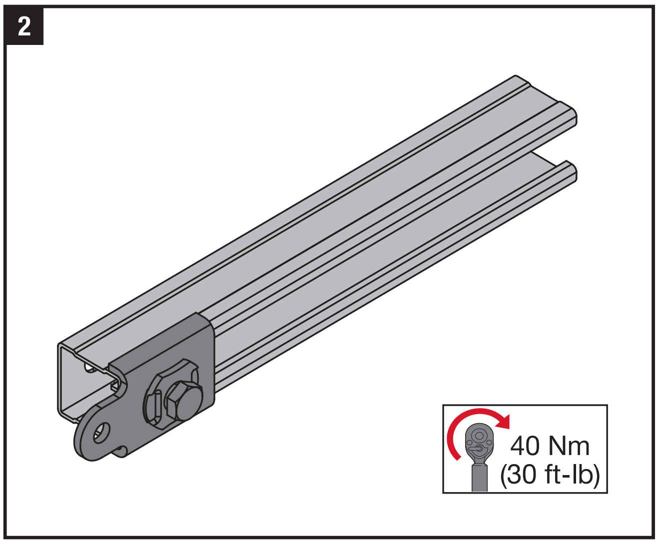
Instruction for use MQS-C/CD

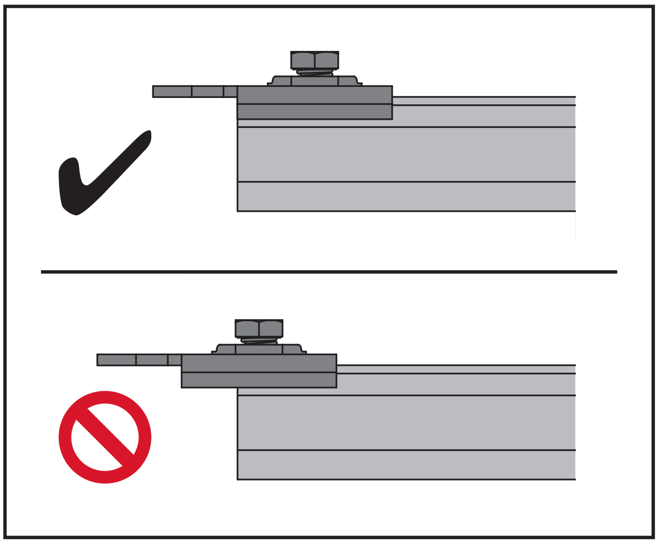
MQS Seismic System





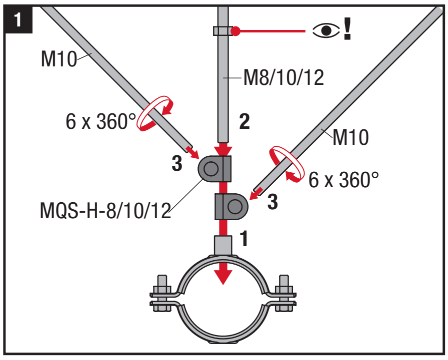


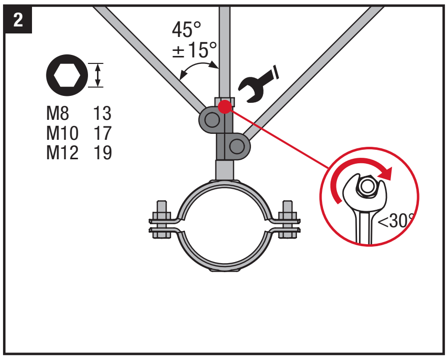


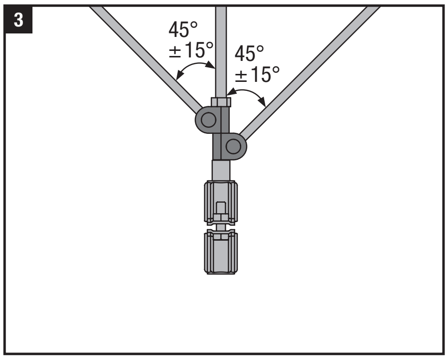


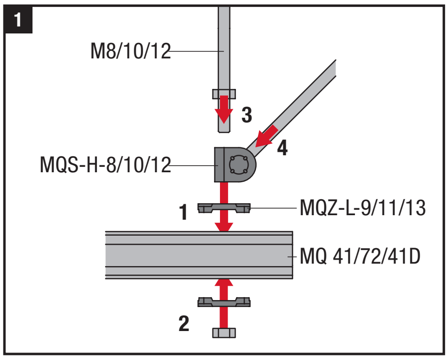
Instruction for use
MQS-H

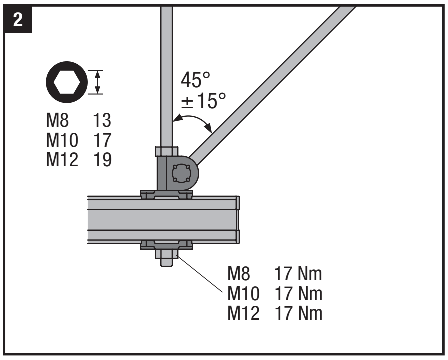
MQS
Seismic System

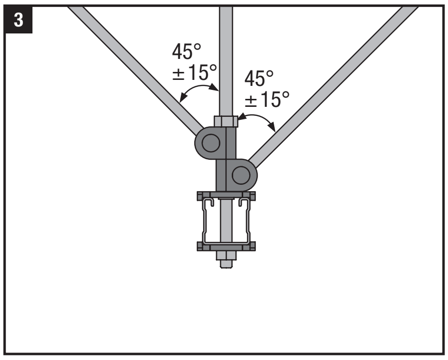






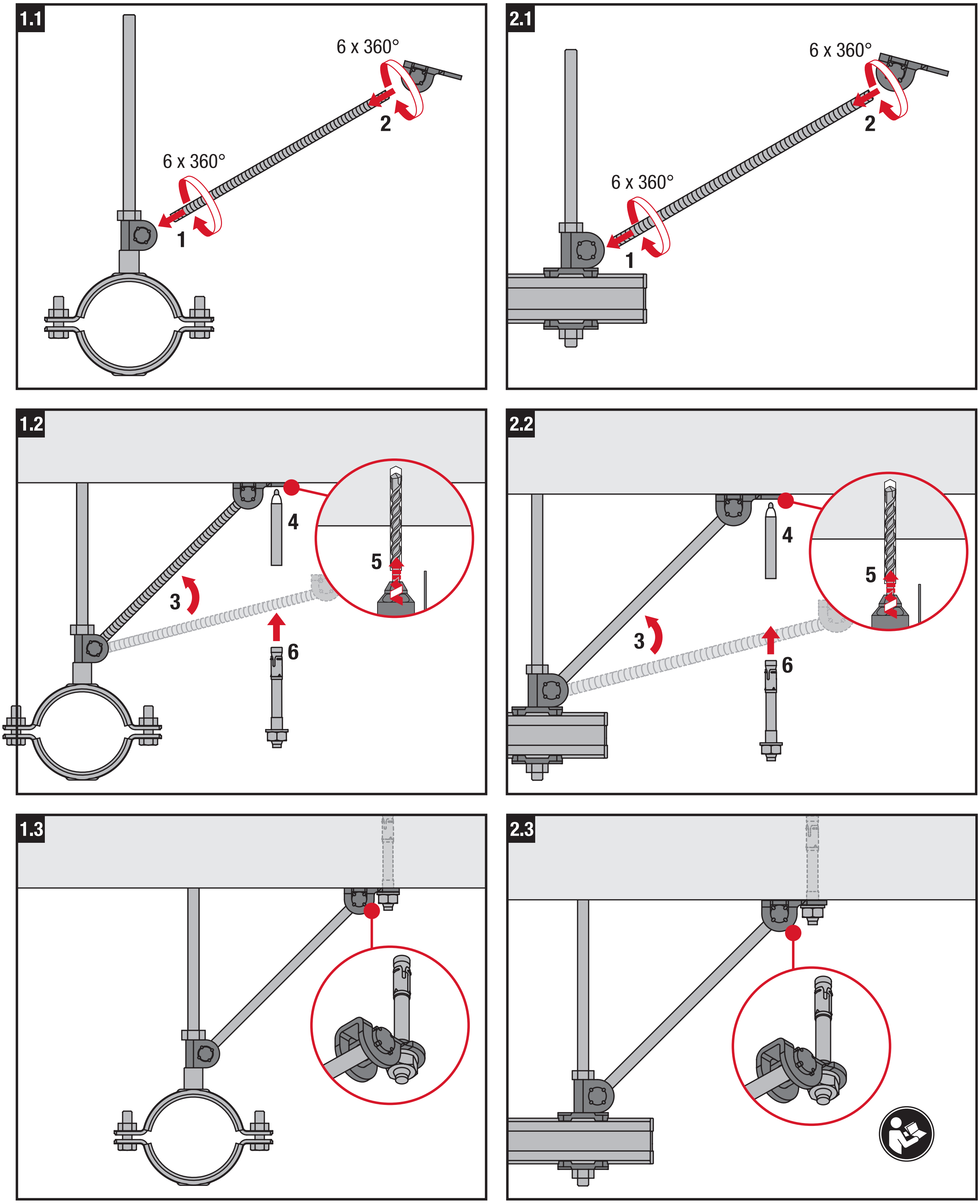






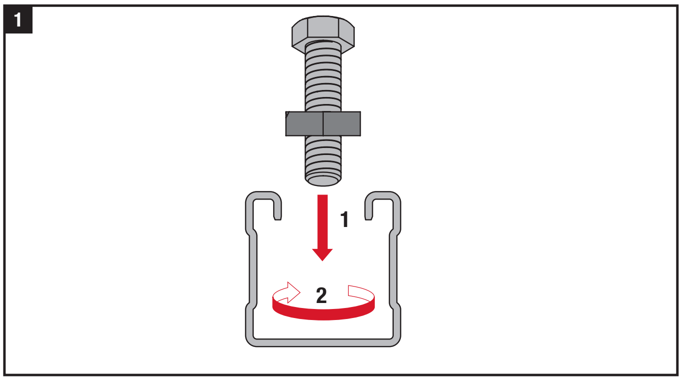
Instruction for use MQS-CH

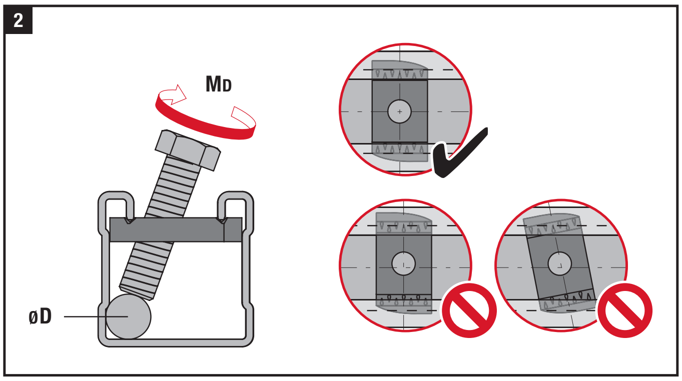
MQS Seismic System

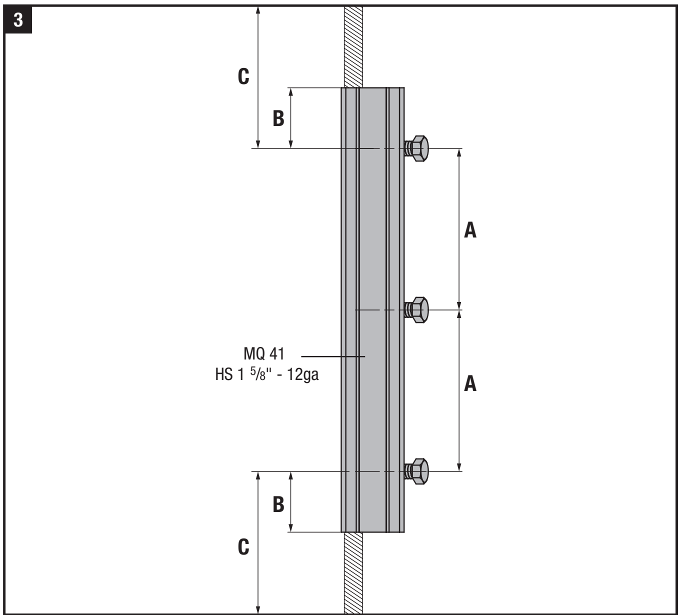


Instruction for use
MQS-RS

MQS
Seismic System







øD	MD	max A	max B	max C
M10 / 3/8"	11 Nm 8ft-lb	330mm / 13"	100mm / 4"	150mm / 6"
M12 / 1/2"		450mm / 18"	100mm / 4"	150mm / 6"
M16 / 5/8"		580mm / 23"	100mm / 4	150mm / 6"

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