CO-CONSTRUCT

Supporting Services from Structure

Guidance for a defect-free interface

Compiled by Roderic Bunn and Martin Heywood

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Co-Construct is a network of five leading construction research and information organisations - Concrete Society, BSRIA, CIRIA, TRADA and SCI - who are working together to produce a single point of communication for construction professionals.

BSRIA covers all aspects of mechanical and electrical services in buildings, including heating, air conditioning, and ventilation. Its services to industry include information, collaborative research, consultancy, testing and certification. It also has a worldwide market research and intelligence group, and offers hire calibration and sale of instruments to the industry.

The Construction Industry Research and Information Association (CIRIA) works with the construction industry to develop and implement best practice, leading to better performance. CIRIA's independence and wide membership base makes it uniquely placed to bring together all parties with an interest in improving performance.

The Concrete Society is renowned for providing impartial information and technical reports on concrete specification and best practice. The Society operates an independent advisory service and offers networking through its regions and clubs.

The Steel Construction Institute (SCI) is an independent, international, member-based organisation with a mission to develop and promote the effective use of steel in construction. SCI promotes best practice through a wide range of training courses, publications, and a members advisory service. It also provides internet-based information resources.

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Supporting Services from Structure

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Introduction

Most new buildings require a labyrinth of ducts and pipes, together with miles and miles of cables. All of these need to be supported in a way that safely transfers the load without causing damage to the services or to the structure.

The numerous locations from which the services can be suspended provide the building services engineer with many options at the design stage and offer the flexibility to overcome unforeseen difficulties that may arise during installation. However, achieving the time and cost saving benefits of innovative suspension systems requires close and early co-ordination between the building services design and that of the structure. As is often the case in building design and construction, the success or failure of a project depends as much on the design of the interface as it does on the design of the individual beams, columns and building services systems.

This guide, the fourth in a series called Interface Engineering Publications, aims to provide guidance on the best ways to engineer the interface between structural design and services distribution. BSRIA and the SCI have pooled their technical knowledge to provide structural and services engineers with consistent, interlocking advice.

Much of the material in the publication is repackaged from existing BSRIA and SCI guidance. Details of the original publications, relevant European and British Standards and other references for further reading are provided at the end of this publication.

The publication begins with an introduction to the design issues faced by structural and building services engineers and examines the implications of certain key design decisions on the integration of the building services into the structure. There are many ways in which the services may be attached to the structure and several of the most common options are discussed in detail. These include fixings to beam flanges, steel decking and solid concrete slabs.

Many proprietary support systems have been developed in recent years to cater for all shapes, sizes and weights of building services. This publication does not give specific advice on the installation of particular systems or components, as most manufacturers produce comprehensive guidance for the design and installation of their products. However, much of the guidance presented in this publication will be applicable to the common types of support system available in the UK and elsewhere.

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Roderic Bunn, BSRIA

August 2004

How to use this guide

Advice about the requirements of the structure to facilitate the suspension of mechanical and electrical services will be found in yellow-tinted boxes.

Advice about suspending mechanical and electrical services from structural elements will be found in the blue-tinted boxes.

Comments marked by ▪ link to structural engineering sections listed under *also see*.

Comments marked by ▪ link to services engineering sections listed under *also see*.

Comments marked by ▪ denote a link common to both specialisms.

Key services watchpoints

- [ ] Essential services engineering messages from the guide

Key structural watchpoints

- [ ] Essential structural messages from the guide

See also

1 **Links** to services sections
2 **Links** to structural sections
3 **Links** to common sections

Further reading to support this guide

Standards for structural and services design

Glossary for definitions of terms

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The clients' guide to

Services issues

Structural elements such as steel decking, concrete slabs and beams of all kinds are regularly used to support mechanical and electrical services in buildings. The method by which these services are supported by the structure will depend on the particular circumstances of each installation, such as the overall load, the position of suitable fixing points on the supporting structure and the attachment options for the item being suspended.

Key services issues

Building services distribution systems, such as pipework, ductwork and cabling, are usually positioned within buildings using a range of mounting and suspension systems. Plant rooms aside, the majority of services are suspended from above using support systems comprising three major components: the fixing which is attached to the building structure, the suspension element itself, (the length of which can be adjusted to position the service at the right height), and the attachment or sling that is attached to or around the service.

The range of building services commonly suspended or supported by building structural elements includes:

- ☐ Fan coils and air handling units
- ☐ radiant heating and cooling emitters (radiant tubes, radiant panels, chilled beams)
- ☐ cable trays
- ☐ ceiling grids
- ☐ luminaires and lighting systems
- ☐ ductwork
- ☐ trunking
- ☐ busbars
- ☐ pipework
- ☐ large signs and indicator displays
- ☐ decorative objects.

The design process

The steps in a typical design process are given below. Not all the steps will be formally laid down on paper for all installations, but most of these issues will have to be considered at least informally at some stage, possibly by the installer:

☐ Objectives and specification: what needs to be suspended and where?

1 ☐ Constraints: gather information on loads and design constraints (such as corrosive atmosphere, fire rating requirements, type of building structure).

☐ Select the suspension system

2 ☐ Select configuration type: choose spacing and positions of suspension assemblies.

☐ Select safety margins and redundancy limits: decide on appropriate safety factors.

1 ☐ Select system components: choose suitable components.

☐ Risk assessment and design review.

The risk assessment should include an assessment of the hazards posed by the suspended load and the risk to those nearby. The designer should then check that the finished design meets the objectives, and amend it before proceeding with the project.

Some of these steps may need to be reviewed more than once as the design progresses.

Suspension elements

The usual suspension element is a rigid component, usually threaded rod. While this is usually in tension, it also provides some resistance to compressive forces, helping to ensure the rigidity of an installation.

3 An alternative to threaded rod is wire rope-based suspension. While these elements are strong under tension, they provide no resistance to compressive or bending loads. That said, careful design (for example setting wires at angles – see below) can usually provide suitable restraint.

Most threaded rod systems (fixings, threaded rod and associated fittings) are significantly over-specified for most applications, allowing considerable freedom of installation methods. Wire rope systems, on the other hand, tend to be more closely specified against the design load and can be overstressed if incorrectly installed.

Whereas threaded rods are usually mounted vertically, wire rope systems can

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easily be installed at an angle. This significantly increases the range of suspension points that can be used. However it has other effects, such as an increased load on fixings, which must be accounted for in the design.

4 Information about the suspended load will be required. For a simple run of services, all that may be needed is the weight per metre and any limits on maximum support spacings. For complex items of plant, the dimensions, weight, centre of gravity, and suspension attachment points may need to be known.

Consideration should be given to the kind of loads that may be applied to the suspension system. Although most loads in building services applications are static, some equipment may create brief dynamic loads, especially during start-up. Pipework, for example, can undergo a shock loading when pumps are suddenly started or stopped.

Other constraints will be the supporting structure and operating environment of the building. The materials and permissible fixing points should be identified. Any environmental constraints should also be identified, such as a corrosive atmosphere. Swimming pool halls, for example, can be very corrosive atmospheres, and require the use of corrosion-resistant hangers.

Load calculations

4 Information on the weight of services to be suspended, such as the weight per metre of items such as pipes and ductwork, should be obtained from manufacturers and system suppliers.

Designers should check that these weights will reflect the loads to be experienced during services operation. This means that the weights of pipework and terminal units, such as fan coils, should not be given in a dry condition but include the weight of water.

Key services watchpoints

- ☐ Before the design of a suspension system can begin, the suspension requirements – and the constraints imposed by the building structure and operating environment – need to be understood by the designer
- ☐ Once a configuration has been selected, the system designer must calculate the loads on each fixing to ensure that suitably strong components are specified and check with the structural engineer that the design loads have not been exceeded
- ☐ Designers should check that the weights given to the structural engineer reflect the actual loads to be experienced during building operation, such as fan coils full of water

Figure 1: A wedge-nut system for fixing services to steel decking. ©Lindapter.

See also

1 Essential fastening issues, page 8
2 Fixing services to structure, page 10
3 Wire rope fixing systems, page 14
4 Table 2, page 9

Further reading on page 20

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Structural issues

The responsibility of the structural engineer is not to design, fit and forget. While building services engineers may be very adept at making do with whatever structure is presented to them, and often improvising the suspension systems, true interface engineering means that services and structural engineers must address the critical design issues. Optimising the fixing systems will lead to better and safer design, and a faster and more cost-effective installation.

Figure 2: A Lindapter TR60 services re-entrant attachment to steel decking. ©Lindapter.

Structural perspectives

Decisions made by structural engineers will have significant effects on the installation and performance of the building services. Similarly, the requirements of the building services will have implications for structural design.

Member resistance

In selecting suitable section sizes for the beams and columns, structural engineers need to make an allowance for the weight of the building services. This is true whether the services are suspended directly from the beams or from the floor slabs or secondary members.

Unlike the building services engineer responsible for designing the support system, it is unlikely that the structural designer will know the exact nature or weight of the services to be supported at the time the structure is being designed. Therefore, the design must be based on estimates of the likely services weight, usually based on experience.

Typically a value of 0·5 kN/m^2 is used in design, although higher values might be necessary in heavily-serviced buildings

Deflection

The choice of beam section size is often determined not by the required section capacity or member resistance at the Ultimate Limit State (ULS), but by the need to limit deflections at the Serviceability Limit State (SLS). It is common to specify the maximum permissible deflection due to the imposed (live) load. Deflection limits recommended by *BS 5950-1:2000 Structural use of steelwork in building* are given in Table 1.

Where services are supported by beams, the building services engineer should ensure that the services are able to withstand deflections equal to these limits. It should be noted, however, that the total deflection of the beam might be greater than these limiting values because of the additional deflection caused by the self-weight of the beam and the weight of the concrete slab (the dead load).

Some dead load deflection will occur before the services are installed and it is important for services designers and contractors to recognise that the beams might not be horizontal or at the same level along the length of the building at the time that the buildings services are being installed. In some cases, beams can be pre-cambered to off-set the effects of dead load, but where this is not possible, services should

Services engineering issues

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be supported in a way that allows the levels to be adjusted.

Choice of floor type

1 The use of support systems that fasten to the underside of steel floor decking provide the building services engineer with considerable choice regarding the location of the services and their supports, without the need for costly site activities such as drilling into the concrete slab. However, advantage can only be taken of this convenient means of support if a suitable floor type is chosen.

As this is one of the first decisions taken in the building design process, clients should recognise the importance of including building services engineers in the decision-making process at the earliest possible stage.

Fire protection

In choosing fire protection for the beams, structural designers should take into account the need to install services, particularly in cases where a mechanical connection has to be made to the beam flange.

2 Board fire protection should only be used where contractors are not likely to support services from the beams. The act of cutting away the board to accommodate clamps would compromise the fire protection. With fire 3 retardant blankets or cement-based spray protection systems, a wire rope system can be used to support the services. Again, the direct attachment of clamps to the beam flanges will not be possible.

Intumescent coatings are probably the most favourable fire protection solution where flange clamps are to be used, although care must still be taken to ensure that the fire protection system is not damaged during the 4 installation of the building services.

Key structural watchpoints

- ☐ Structural engineers should alert clients to the importance of including building services engineers in the decision-making process at the earliest possible stage
- ☐ While 0·5 kN/m^2 is often used as a rule of thumb value for the weight of services, a higher value might be necessary for heavily-serviced buildings such as laboratories or industrial buildings
- ☐ The design of the beams is often governed by the maximum permissible deflection due to the imposed (live) load as recommended by *BS 5950-1:2000 Structural Use of Steelwork in Building*
- ☐ In choosing fire protection for beams, structural engineers should consider the options for installing services, particularly where mechanical connections to beam flanges may be required

Table 1: *BS 5950-1: 2000* limits for calculated deflections due to imposed loads.

Category	Deflection limit
Cantilevers	Length/180
Beams carrying plaster or other brittle finish	Span/360
Other beams (except purlins and sheeting rails)	Span/200

See also

1 Figure 5, page 11
2 Figure 14, page 18 (and text)
3 Wire rope fixing systems, page 14
4 Further reading (IEP2)

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An introduction to

Essential fastening issues

The choice of fixing will depend on a variety of factors: whether the slab is of lightweight steel or heavyweight concrete, and whether the building is new or being refurbished. Designers will be seeking to provide the simplest and quickest configuration to install, while meeting the requirements for load stability and easy access, as well as any requirement for redundancy should a part of the suspension system fail.

Figure 3: The suspension of different services from the structural steelwork is often improvised by multiple trades passing through the same area. This can create conflict and delays, and increase the costs of the project.

Key design factors

A designer tasked to choose a suspension system will be seeking to reach a compromise between a number of requirements, and there will not be a single correct configuration for any particular suspension requirement. To assist in choosing a configuration, there are some sources of industry guidance on the suspension of different services such as HVCA *DW144* or the *CIBSE Guide B*.

Once a suspension system has been selected, suitable components will need to be chosen. Components are given a rated safe working load, and in many applications it will be acceptable to design a system that operates at or just slightly below that rating (Table 2).

The integrity of a suspension system and the load to be supported not only depends on the strength of the suspension system, but also on the stiffness and strength of the supported load. Stiff loads will tend to successfully transfer loads to a number of adjacent suspension assemblies, while more flexible loads may only transfer the load to the adjacent suspension assembly.

Producing a redundant system may not simply be a matter of applying suitable safety margins, but may also require extra suspension points, or reinforcement of the load.

For light loads, in the order of 1 kN per anchor point (100 kg vertically suspended load), redundancy can usually be assumed if the load can be transferred to two adjacent fixings in the case of linear systems, or three adjacent fixings in the case of bi-directional systems. For higher loads, a full assessment may be required to take account of the stiffness of the supported structure.

Component load limits

A safe working load (SWL) or working load limit (WLL) will be stated by the supplier as being the maximum load the component or system is capable of handling. This may be calculated in a number of ways, but is typically between a quarter and a fifth of the design ultimate tensile strength. This helps provide a margin for any inconsistencies in installation, and normal degradation of the component over its installed life (Table 2).

All of these ratings may be altered (usually decreased) depending on the application of

	Services engineering issues
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the component. Components with a fire rating may have their standard safe working load reduced to ensure they provide adequate strength under extreme conditions. (Certified loading data is available from some fixings manufacturers for different exposure times under conditions of standard fire curves.)

Designers must know the load factors of the components they are intending to have supported, and the conditions in which they are expected to operate. If in doubt, checks should be made with the component supplier.

Table 2: Typical safe working loads for common fixings. ©BSRIA.

	Fixing type	Typical range of safe working loads (kg)	Site tests advised?
2	*Wire rope (capacity relates to diameter)*	10 – 325	
	Toggle end fixing on wire (capacity matches that of wire)	10 – 90	
3	*Open coil attachment M6*	90	
	Open coil attachment M8	150	
	Clamp for steelwork	45 – 300	
	Clips for steelwork	60 – 90	
4	*Powder-actuated fixing to steelwork (10 mm)*	200 (approximate)	✓
	Powder-actuated fixing to concrete (non-drilled)	40 (very approximate)	✓
	Powder-actuated fixing to concrete (pre-drilled)	90 (very approximate)	✓
	Powder-actuated fixing to composite decking	Depends on the concrete type	✓
5	***Drilled fixings into solid concrete (30 N/mm²)***		✓
6	*Socket anchor M6*	200 – 300	
	Socket anchor M8	300 – 400	
	Ceiling hanger	80 – 200	
7	*Rubber expansion anchor*	Depends on the base material	✓
8	*Wedge nuts M10*	200 (approximate)	✓

Key services watchpoints

✓

- ☐ Designers must know the actual loads of components, and the conditions in which they are expected to operate
- ☐ Designers should obtain details of the safe working load or working load limit declared by the supplier as being the maximum load a component or system is capable of handling
- ☐ Designers should be aware that components with a fire rating may have their standard safe working load reduced to ensure they provide adequate strength under extreme conditions

Key structural watchpoint

✓

- ☐ The structural engineer hould ensure that the services load assumed during the design is not subsequently exceeded.

See also

1 Further reading, page 20
2 Wire rope fixing systems, page 14
3 Figure 9, page 14
4 Powder-actuated fastening, page 15
5 Table 3, page 13
6 Figure 8, page 13
7 Figure 7, page 12
8 Figure 5, page 11

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Issues to address when

Fixing services to structure

Contemporary forms of building construction provide building services engineers with many opportunities for supporting the mechanical and electrical services. The choice of attachment point to the structure will depend on a number of factors, including the layout of the structural frame, the type of floor construction used, the size and weight of the services to be supported and their location within the building.

Figure 4: A Slimdek 2 wedge suspension hanger developed for the Corus SlimdekW system. ©Lindapter.

Primary steelwork

Services may be supported directly from the main structural beams either using clamps attached to the bottom flange or wire rope passed round the section. Several types of clamp are available to suit attachment to parallel flanges and tapered flanges. Where necessary, attachments can be made to inclined flanges using a swivel-flange clamp.

Small services, such as cables, may be carried on top of the lower beam flange, held in place by clips. Alternatively, if the building use and finishes permit, cables may be carried on cable trays attached directly to the columns.

The advantage of supporting services directly from primary steelwork is that the weight of the services is usually small compared to the other dead and imposed loads carried by the beams and columns. Consequently, the additional loads can be carried without a significant increase in section size.

1 In most cases, the beams and columns will usually be designed for service loads, whether or not the services are carried directly by the steel members. The loads will be taken by the primary steelwork at some point in the load path.

The disadvantage of supporting the services directly from the primary steelwork is that the locations of supports are restricted to points on the structural grid. Where services run perpendicular to the beams supporting them, the resulting span might exceed the maximum unsupported length for the service duct or pipe.

Secondary steelwork

2 In some cases it may be possible to suspend the services from secondary steelwork such as purlins or side rails. Where purlins are used, the same options exist as for structural beams (wire rope round the section or clamps attached to the flanges).

Special clips are available for attachment to purlin flanges or, where heavy duty support is needed, to the purlin web. Cables may be carried in specially-designed cable trays that fit inside the purlin flange.

Unlike primary structural steelwork, purlins and side rails are made from light gauge steel and are designed to support relatively small loads. Care must therefore be taken to ensure that they are capable of supporting the services

Services engineering issues

Structural issues

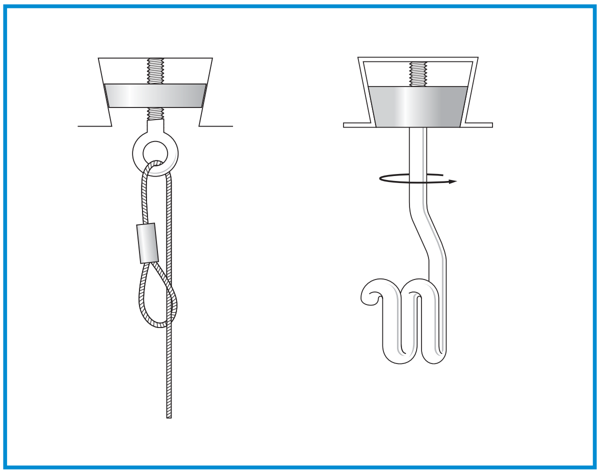

Figure 5, left: An eye adaptor used with a wedge nut. *Right:* a wedge nut and open coil attachment. ©BSRIA.

in addition to the other design loads such as the cladding dead load and the weight of snow. Purlin manufacturers are able to advise on the safe working loads of their products, including service loads.

The advantage of using secondary steelwork is that many more potential attachment points are provided than would be the case with primary steelwork, thereby reducing the span of the services and maximising the options for the building services engineer.

Steel decking

A popular alternative to supporting the services from the primary or secondary steelwork is to hang them from the underside of the steel decking used to form the composite floor slab. Many decking profiles have re-entrant slots into which wedge-shaped mechanical fixings may be inserted, as shown in Figure 5. This simple device is easy to install and will normally have a safe working load of at least 1 kN (depending on the design of the fixing, the steel decking and the gauge of the threaded bar).

Key structural watchpoints

- ☐ Designers should be aware that where services run perpendicular to a beam intended to support them, the resulting span might exceed the maximum unsupported length for the service duct or pipe
- ☐ Structural (and services) designers should check the purlin manufacturers' guidance for safe working loads when using the purlins to support services

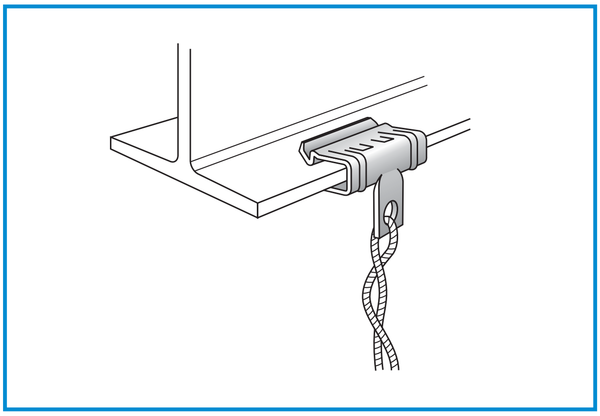

Figure 6: A typical clamp, with integral eye and caddy-type clip, used for supporting light loads. ©BSRIA.

See also

1 Table 1, page 7
2 Wire rope fixing systems, page 14

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Fixing services to structure 2

Special fixings are also available for the Corus Slimdek® flooring system (Figure 4). As with the wedge fixings, the special attachment takes advantage of the re-entrant shape of the profile and is mechanically locked in place to form a strong connection to the decking. A safe working load of 1 kN is quoted by the manufacturers.

The advantage of suspending the services from the decking is that the re-entrant slots are typically only 100-150 mm apart, providing considerable choice regarding the location of the services. Provided that the safe working load of the floor slab is not exceeded, new services can easily be attached at any time over the operating life of the building.

Concrete decking

The major issues for selecting a method of attachment to concrete decking are:

- ☐ The type of structure
- ☐ the base material
- ☐ the applied load
- ☐ the application dimensions
- ☐ temperature ranges
- ☐ the corrosion conditions
- ☐ the attachment configurations.

Table 3 identifies the common fixings for different base materials. Many concrete structures will contain reinforcing bars or pre-stressing bars or cables.

Cutting or damaging these reinforcement elements can significantly affect structural strength. If the reinforcement is hit, the fixing should either be relocated or the reinforcement be cut - but only with the permission of the structural engineer.

1 Drilled fixings may be used with an open coil attachment. M6 and M8 versions require 8 mm and 10 mm hole diameters respectively drilled typically 25 mm and 30 mm deep. They are relatively strong and, due to the shallow embedment depth, should avoid hitting the reinforcement bar.

Voided construction

In voided construction, fixings are not straightforward. Suitable methods include toggle fixings, plug and screw fixings, expanding anchor bolts (Figure 7), and drop rods (the latter for heavy loads). Toggle fixings are designed to penetrate the void. They are usually only suitable for light loads such as light fittings and cable conduits, but not for suspended ceilings.

2 It is vital that the quality of the void is known. If the concrete is weak due to cracks, poor casting or lack of thickness, either the act of drilling into the void will damage the concrete, or it will break under the load.

Hammer-set socket-anchors (also known as drop-in anchors) are used for suspension of services. The anchor is usually set using a punch and club hammer, but some manufacturers offer setting adaptors for use in hammer-drilling machines. These speed up setting and ensure optimum expansion.

Plug and screw and expanding anchor bolts can be inserted into the centre of the rib. It is vital that there is enough space between the reinforcing bars. The concrete around the reinforcement in the ribs can be poorly compacted and may need repairing to provide an adequate anchor (Figure 8).

Drop rods are suitable for heavy loads, and can be fitted through the slab with a fixing plate on top. This is only suitable where a screed covers fixings. As reinforcing bars can be very close they may not provide room for a rod.

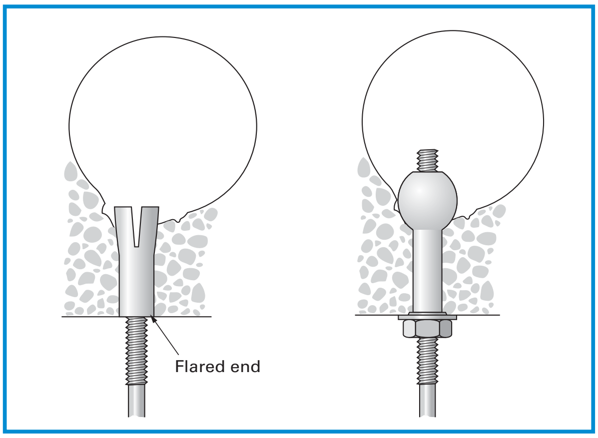

Figure 7: Methods of locating fixings in hollowcore concrete. *Left:* A hammer-set socket anchor, and *right:* a rubber expansion-anchor with a flared end. ©BSRIA.

Services engineering issues

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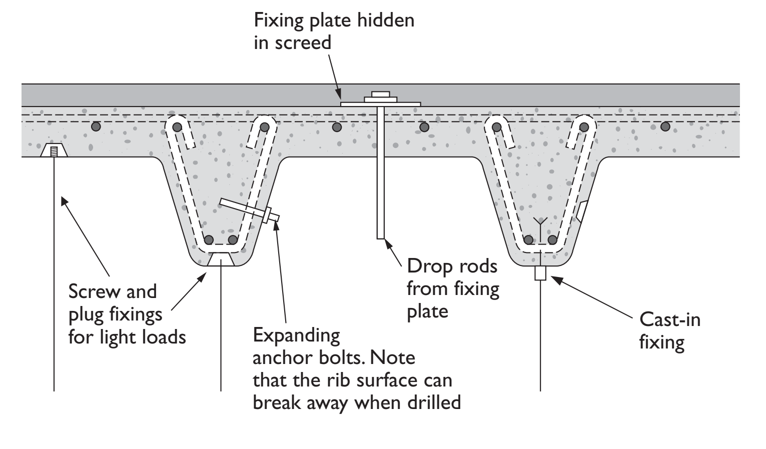

2 ***Figure 8:*** Possible fixings to soffits of exposed ribs. Source: BSRIA.

Table 3: Common fixings for a range of materials. ©BSRIA.

Building structure	Other factors	Suggested fixing types
Exposed steel work	Access to wrap rope around structural element (may be purlin or channel-fixed between sections)	Direct attachment using wire-rope loop (or indirect attachment into channel itself using adaptor)
	No access to wrap rope around structural element	Clamps and clips
		Powder-actuated fixing or special clips
		Toggle inserted through hole drilled in horizontal flange
3 *Solid concrete*	Suitable for powder-actuated fixings (site tests may be required to check)	Powder actuated fixings (pre-drilled in preference to non-drilled)
	Not suitable for powder-actuated fixings (site tests may be required to check)	Drilled-in fixings
2 *Hollowcore concrete*		Drilled fixings – rubber expander or socket anchor with flared end
Profiled roofing	Not open to elements	Toggle inserted through drilled hole
Composite decking	Profile suitable for wedge nuts	Wedge nuts
	Plain profile	Powder-actuated fixing or special clips
		Drilled fixings

Key services watchpoints

- ☐ The cutting or damaging of reinforcement elements can significantly affect structural strength and should therefore only be carried out with the permission of the structural engineer
- ☐ When attempting to penetrate voided construction, it is vital that the quality of the void is known to prevent cracks or breakage during the fixing process
- ☐ When attempting to fix to concrete ribs, the services engineer should seek structural advice on whether the concrete around the reinforcement in the ribs needs repairing to provide an adequate anchor

See also

1 Table 2, page 9
2 Further reading (IEP3 Figure 16) page 22
3 Powder-actuated fastening, page 15

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An introduction to

Innovative fastening methods

Services and structural engineers are no longer limited to the humble threaded rod in order to support or suspend building services. A number of alternative fixing methods are now available that are often faster to install and more cost-effective. However, they all have their strengths and weaknesses, and before deciding on a fixing system services designers should liaise closely with their structural colleagues to identify the most suitable fixing for the particular context.

Wire rope fixing systems

Wire rope suspension is increasingly being used for mounting building services components. There are major advantages of flexible positioning and installation productivity benefits. For example, where threaded rods are usually mounted vertically, wire rope systems can easily be installed at an angle. This significantly increases the range of suspension points that can be used.

The majority of conventional suspension systems have vertical suspension elements, and as such fixings and suspension elements are subjected to purely tensile loads in a vertical direction. One of the advantages of using wire rope systems is that the rope can easily be installed at an angle to allow for different anchor points for fixings. However when taking advantage of this feature, designers must take into account the fact that this will apply shear loads to fixings, and will increase the total load on the fixing and wire (Table 4).

Most wire rope used in the UK will be compliant with *BS 302*. Compliance and test certificates can usually be obtained from the supplier. Alternatively, where the rope is supplied as a component of a suspension system, the supplier may give an overall rating for all the components of the system.

Some way of attaching the wire rope to other pieces of equipment such as fixings or the suspended building services components will be required. This may be through a device or clamp directly gripping the rope, or the rope may be looped to form an eye that may be placed over suitable attachment points.

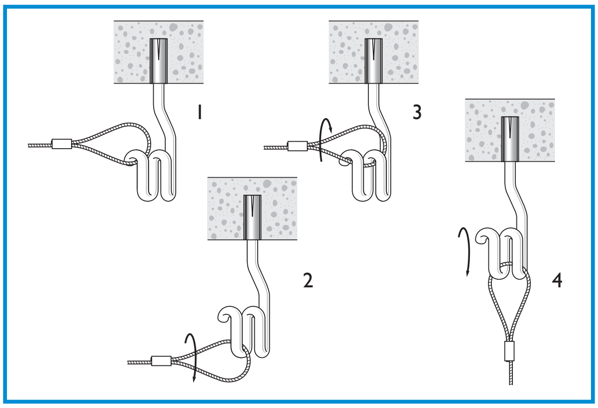
An eye may be formed in a rope in a number of ways, but the most common way is where the ferrule is crimped around the adjacent lengths of rope. The eye may be a soft eye, simply formed by the loop of the rope, or a thimble may be inserted to ensure that the eye is held open and retains its shape. Some fixings may have an integral eye. The free end of the wire is fed through the eye, and then pulled tight through the loop of the rope.

Some wire rope grips intended to be used to form an eye in a rope can be used to join two separate lengths, but if they are not designed for this application then there is a risk of failure. Ideally, a wire rope of the correct length should be obtained, but where this is not possible designers and installers must ensure they are using joining methods approved by the component manufacturer.

Table 4: The effect of wire rope angle on the rope and fixing load. ©BSRIA.

	Loading of each wire and fixing		
Angle from the vertical	*Vertical load in kN*	*Lateral load in kN*	*Total load in kN*
0°	1·00	0·00	1·00
1°	1·00	0·27	1·04
30°	1·00	0·58	1·15
45°	1·00	1·00	1·41
60°	1·00	1·73	2·00

Figure 9: The use of wire ropes with open-coil attachments fitted into structural slabs. ©BSRIA.



Services engineering issues

Structural issues

©BSRIA

Figure 10: Powder-actuated fastening (otherwise known as shot firing) is suitable for many types of structural slab.

Powder-actuated fastening

Powder-actuated fastening (sometimes referred to as shot-fired fixing) is a portable system for fastening building services supports to steel, concrete and masonry. The system comprises a nail driven into the base material via a piston that is powered by a small explosive cartridge.

The system combines into a single process the conventional two-stage approach of drilling a hole and then knocking in an anchor.

A range of different nails and connectors are available to suit numerous applications and loads. Irrespective of base structure, the most common technique is to fix a special clip that will have the loop of the wire rope already located in it.

The nature of concrete means that powder-actuated fixings applied without predrilling may not always work, as the aggregates close to the surface are likely to cause deflection of the nails. Pre-drilling using special drill bits usually overcomes this problem.

Site trials are therefore always required in concrete applications. If tests reveal significant problems, then a technique of pre-drilling should be used. Although pre-drilling adds

Key services watchpoints

- ☐ **Wire rope fixings**
  Suspending loads on wire rope at an angle will add shear loads to the wire, and thereby increase the wire's total load
- ☐ Wire ropes can be looped to create an eye, but some rope products are not designed for this application and may fail
- ☐ Designers should obtain compliance and test certificates from suppliers and ensure the installing contractor is aware of wire-rope product limitations
- ☐ **Powder-actuated fixings**
  Designers should specify that all trades required to install powder-actuated fastenings are trained and certified to the appropriate standard of competency
- ☐ Trial fixings are recommended for all new applications to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used

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cost, improved reliability may mean fewer failed fixings.

Pre-drilled or non pre-drilled application techniques require different clips. Trial fixings
1 are recommended for all new applications to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used. When requested, fixing manufacturers will usually assist in trial fixings.

The powder-actuated fastening tool can contain multiple cartridges and fastenings, making fixing a quick and easy process.

1 Powder-actuated fastenings can be used to support a wide range of m&e services including ductwork, fan coil units, electrical tray, luminaires and pipework. The typical load range is between 40-90 kg per fixing.

Time and cost savings

BSRIA has observed that the use of powder-actuated fastenings can reduce installation times by up to 65% in comparison to the more traditional two-stage approach that uses a drilled hole and knock-in anchor.

BSRIA has also found that the use of powder-actuated fastenings can result in a total installed cost saving of 36% per fixing in comparison to the traditional approach. However, powder-actuated fixings are usually viable only where a significant number of fixings is needed.

Approval for powder-actuated fastening must be obtained from the structural engineer. Approval may also be required from the local authority, for example where noise break-out may be a problem.

The benefits of these devices can be fully realised when a design team uses installation drawings with common levels. This will simplify the process of setting-out, particularly if infra-red setting-out devices are used to locate the fixing points.

Adhesive fasteners

1 Adhesive fasteners for building services supports can remove the need to drill or shot-fire fixings into the structure. Once the surface has been primed, the adhesive pad can be fixed quickly and easily to steel, concrete, glass, and most surfaces provided they are flat, smooth, dry and clean. Adhesive fasteners have a safe working load from 5-15 kg.

Figure 11: adhesive fasteners are ideal for supporting lightweight services. ©BSRIA.

The system is quick, quiet and easy to install using purpose-designed application tools. An extension pole can also be used to fix the supports to the slab without climbing ladders. Surface bonding of the adhesive fasteners avoids the need for structural penetration.

Adhesive fasteners are ideal for supporting general, lightweight services including small diameter pipework up to 50 mm, conduit and electrical data to 20-25 mm, and fire cables up to 30 mm. Adhesive fasteners are limited to loads of up to 15 kg per fixing. Designers should check that the use of adhesive fasteners are approved by all relevant project parties.

Time and cost savings

2 BSRIA has observed that the use of adhesive fasteners can reduce installation times by up to 47% in comparison to the more traditional approach that uses a drilled hole with inserted plastic plug and screw. BSRIA has also calculated that the use of adhesive fasteners can result in a total installed cost saving of 31% in comparison to the traditional approach.

The performance of this product is largely independent of operator skill and minimal training is required. Adhesive fasteners are not suitable for use on painted or plasterboard surfaces.

Figure 12: The Hilti MQ modular channel system is designed to speed up the installation of supports for m&e services.

Channel support systems

Channel support systems are designed to speed up the installation of supports for m&e services. BSRIA has studied the benefits of two such systems and identified their virtues and shortcomings.

The Hilti MQ channel system

2 BSRIA studied the site application of the Hilti MQ channel installation in 2002. BSRIA found that such systems are simple to use, especially if the installer has prior knowledge of a traditional channel system.

Channel connections are made using a quarter turn push-button channel nut, which is a single component and does not require a bolt and back nut. Different sizes of channel are available, and the Hilti system comes in single channel sizes from 21-72 mm, and 41 mm double-channel profiles ranging from 41·2-124 mm.

A pipe-ring saddle can be installed onto a piece of channel without the need for tools. The saddle is attached to the channel with a quarter turn, and then slid along to the correct location. The threaded rod is then inserted and the locknut tightened by hand. It is important that the designer selects the correct size of component to avoid under-engineering.

Time and cost savings

Compared to traditional channel systems and fittings, the rapid installation system can take

Key services watchpoints

- ☐ **Powder-actuated fixings**
  Trial fixings are recommended to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used
- ☐ The cartridge and nail type must be correct for the base material, as the use of a powder-actuated fastening to the underside of a concrete slab with a high aggregate content may cause spalling
- ☐ Approval for powder-actuated fastening must be obtained from the structural engineer and also from the local authority where noise break-out may be a problem
- ☐ **Adhesive fasteners**
  Adhesive fasteners are limited to loads of up to 15 kg per fixing. Designers should check that the use of adhesive fasteners are approved by the project parties

See also

1 Table 2, page 9

2 BSRIA site feedback data (not yet published)

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Innovative fastening methods 3

Left: figure 13: Halfen channel laid out prior to a concrete pour. ***Below, figure 14:*** A drop-rod fitted to the Halfen channel. Note the thermal insulation.

54% of the intallation time. There can also be a reduction in the number of fixing components required. Disassembly of installed support systems is also more rapid than traditional systems - important if changes are likely to be needed later.

The double-channel profiles can replace heavy-duty welded support systems, and eliminate hot works operations on site.

Cast-in channel systems

Cast-in channel is a system that involves steel channel being cast into concrete floor slabs in order to provide in-built support for services and architectural systems.

Items can be secured to a slab significantly faster with integrated cast-in channel than a plain concrete slab. The key criteria are the extent of the area to be covered by the support mechanisms, and the spacing required between parallel channel lengths.

Time and cost savings: Halfen channel

2 BSRIA site research carried out in 2003 has shown that the unit time taken to fix a drop rod assembly to cast-in Halfen channel is 2·5 minutes. By contrast, the time taken to measure and mark a fixing point, drill a hole, insert an anchor and fix a drop-rod assembly into a plain concrete slab was measured at 5·5 minutes.

At an installed cost of £11.40 per linear metre (at 2003 prices), the investment in cast-in channel needs to be off-set by cost and time savings by services and architectural trades. This means early input by the services contractors that wish to use cast-in channel in order to determine the support requirements.

The services and architectural trades who use the channel system also need to demonstrate time and cost savings when preparing budgets and cost programmes. If this is not done, the integration of cast-in channel will increase concrete slab costs without necessarily creating downstream savings. Likewise, if insulation has to be fitted to the underside of the slab after the channel has been cost-in, thereby concealing the channel, then installation savings will not necessarily accrue (Figure 14 above).

Sheet metal brackets

Another innovative method of supporting services from slabs involves a non-proprietary method of using sheet-metal brackets. Such brackets can be installed by the pipework contractor to speed up the installation of branch pipework.

The brackets are pre-drilled to receive the pipe hanger drop rods. This can greatly simplify the installation process for the mechanical contractor because it eliminates the need to measure, mark, drill and fix anchors in the ceiling slab.

Figure 15: Chilled water pipework suspended from a sheet-metal bracket installed by a ceiling contractor.

Co-ordination is needed between different work packages in order to deliver an integrated approach. If this is achieved, then savings can be generated in the number of different trade visits to work areas, installation time benefits and a reduction in the number of anchors installed in reinforced concrete slabs.

Polymer pipe clips

Polymer pipe clips are easy to release and re-locate, and are available in a wide range of sizes in imperial and metric measures. They can also be easily adjusted. They are also designed to clamp around insulation, enabling a continuous vapour seal.

Designers need to choose the appropriate clip suitable for solid or insulated pipework.

Time and cost savings

During site research carried out in 2000, BSRIA found that polymer pipe clips were relatively quick to install, taking typically 44% of the time needed for a conventional fitting. They can also cost less than a conventional fitting, typically 10-15% cheaper.

2 Polymer clips tested by BSRIA gave perpendicular pull-test results in excess of 150 kg. The slip tests gave results in excess of 29 kg. On the stud clip, the pull tests gave results in excess of 26 kg and the slip tests gave results in excess of 15 kg.

Key services watchpoints

✓

☐ **Cast-in channel**
Services and structural engineers need to identify the extent of the area to be covered by the support mechanisms, and the spacing required between parallel channel lengths

☐ Design teams need to ensure that the investment in cast-in channel is off-set by cost and time savings by services and architectural trades

☐ Services and architectural trades who use the channel system also need to demonstrate time and cost savings when preparing budgets and cost programmes

☐ **Sheet metal brackets**
Good co-ordination is needed between structural and services contractors in order to deliver an integrated approach to the design and installation of supports

Figure 16: Polymer pipe clips are easy to release and re-locate, and are designed to clamp around insulation.

See also

1 Table 2, page 9
2 BSRIA site feedback data (not yet published)

Further reading on page 20

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Further reading

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Standards

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BS 2092 Grade 1 for Drilling or for Fixing Powder Actuated Fastenings

BS 302-1:1987 Stranded Steel Wire Ropes. Part 1: Specification for General Requirements, British Standards Institution, 1987

BS 302-2:1987, Stranded Steel Wire Ropes. Part 2: Specification for Ropes for General Purposes

*Note that this list is not comprehensive. A great deal of additional information may be obtained from manufacturers and from industry bodies such as the Construction Fixings Association.

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*Note that this list is not comprehensive. A great deal of additional information may be obtained from manufacturers, including Lindapter (www.lindapter.com).

Glossary

Building services terms

Fan coil unit	A device often fitted in the ceiling void and which comprises a fan, heating and/or cooling coil, and an air filter, all housed in a metal casing. The fan-coil unit may be supplied with fresh air from the main air supply ductwork.
Cable tray	Horizontal tray, usually of metal, used to carry power cables and voice and data cables above a suspended ceiling (also underneath a raised floor). Cables may be segregated over two or more trays to prevent electrical interference. Cable tray is commonly suspended from the soffit or from other plant items such as ductwork.
Busbar	A low voltage power cable usually run beneath raised floors or above suspended ceilings, with fittings that enable take-offs to electrical services such as lighting and air conditioning equipment.
Luminaires	A light fitting inclusive of lamp and control gear, housed within a suspended ceiling. Luminaires are often part of an integrated services module comprising fire detectors, public address speakers, motion sensors and acoustic panels. They will be heavier as a consequence.

Structural terms

Composite floor slab	A floor consisting of profiled steel decking and *in-situ* concrete. The two elements act together structurally.
Flange	The projecting element at the top and bottom of an I beam.
Intumescent coating	A coating applied to steel beams or columns that expands to many times its initial thickness when heated, thus providing an insulating layer to the steel.
Primary steelwork	The main structural frame comprising beams and columns.
Purlin	A horizontal beam in a roof, usually made from light gauge steel, which spans between the rafters and supports the roof cladding.
Secondary steelwork	Smaller steel members which transfer loads from the cladding (roof or wall) to the main structural frame.
Serviceability Limit State (SLS)	The point beyond which the specified service criteria are no longer met.
Steel decking	Profiled light gauge galvanised steel sheet which supports the wet concrete during construction and acts compositely with the concrete in service.
Ultimate Limit State (ULS)	The point beyond which the structure would fail.

What are **Interface Engineering Publications?**

Interface Engineering Publications (IEP) are a series of guides that aim to bridge the gaps in technical knowledge at the interfaces between construction packages. The publications involve reformating existing professional knowledge, developed independently by Co-Construct members, into a single source of guidance.

The objective of IEPs are to reduce failures on site, to create greater understanding of shared processes by clients, designers and contractors, and to improve construction quality and the in-use performance of building systems.

Supporting Services from Structure was jointly researched, edited and produced by BSRIA and The Steel Construction Institute in order to provide comprehensive guidance in a single publication. All the information has been drawn from current research and existing publications, and cross-referenced with the latest regulatory requirements.

For more information on Co-Construct visit www.construction.co.uk.

CO-CONSTRUCT

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Introduction

Most new buildings require a labyrinth of ducts and pipes, together with miles and miles of cables. All of these need to be supported in a way that safely transfers the load without causing damage to the services or to the structure.

The numerous locations from which the services can be suspended provide the building services engineer with many options at the design stage and offer the flexibility to overcome unforeseen difficulties that may arise during installation. However, achieving the time and cost saving benefits of innovative suspension systems requires close and early co-ordination between the building services design and that of the structure. As is often the case in building design and construction, the success or failure of a project depends as much on the design of the interface as it does on the design of the individual beams, columns and building services systems.

This guide, the fourth in a series called Interface Engineering Publications, aims to provide guidance on the best ways to engineer the interface between structural design and services distribution. BSRIA and the SCI have pooled their technical knowledge to provide structural and services engineers with consistent, interlocking advice.

Much of the material in the publication is repackaged from existing BSRIA and SCI guidance. Details of the original publications, relevant European and British Standards and other references for further reading are provided at the end of this publication.

The publication begins with an introduction to the design issues faced by structural and building services engineers and examines the implications of certain key design decisions on the integration of the building services into the structure. There are many ways in which the services may be attached to the structure and several of the most common options are discussed in detail. These include fixings to beam flanges, steel decking and solid concrete slabs.

Many proprietary support systems have been developed in recent years to cater for all shapes, sizes and weights of building services. This publication does not give specific advice on the installation of particular systems or components, as most manufacturers produce comprehensive guidance for the design and installation of their products. However, much of the guidance presented in this publication will be applicable to the common types of support system available in the UK and elsewhere.

Martin Heywood, The Steel Construction Institute
Roderic Bunn, BSRIA

August 2004

How to use this guide

Advice about the requirements of the structure to facilitate the suspension of mechanical and electrical services will be found in yellow-tinted boxes.

Advice about suspending mechanical and electrical services from structural elements will be found in the blue-tinted boxes.

Comments marked by ■ link to structural engineering sections listed under *also see*.

Comments marked by ■ link to services engineering sections listed under *also see*.

Comments marked by ◪ denote a link common to both specialisms.

Key services watchpoints

- ☐ Essential services engineering messages from the guide

Key structural watchpoints

- ☐ Essential structural messages from the guide

See also

1 **Links** to services sections
2 **Links** to structural sections
3 **Links** to common sections

Further reading to support this guide

Standards for structural and services design

Glossary for definitions of terms

Contents

The clients' guide to

Services issues

Structural elements such as steel decking, concrete slabs and beams of all kinds are regularly used to support mechanical and electrical services in buildings. The method by which these services are supported by the structure will depend on the particular circumstances of each installation, such as the overall load, the position of suitable fixing points on the supporting structure and the attachment options for the item being suspended.

Key services issues

Building services distribution systems, such as pipework, ductwork and cabling, are usually positioned within buildings using a range of mounting and suspension systems. Plant rooms aside, the majority of services are suspended from above using support systems comprising three major components: the fixing which is attached to the building structure, the suspension element itself, (the length of which can be adjusted to position the service at the right height), and the attachment or sling that is attached to or around the service.

The range of building services commonly suspended or supported by building structural elements includes:

- ☐ Fan coils and air handling units
- ☐ radiant heating and cooling emitters (radiant tubes, radiant panels, chilled beams)
- ☐ cable trays
- ☐ ceiling grids
- ☐ luminaires and lighting systems
- ☐ ductwork
- ☐ trunking
- ☐ busbars
- ☐ pipework
- ☐ large signs and indicator displays
- ☐ decorative objects.

The design process

The steps in a typical design process are given below. Not all the steps will be formally laid down on paper for all installations, but most of these issues will have to be considered at least informally at some stage, possibly by the installer:

- ☐ Objectives and specification: what needs to be suspended and where?
- 1 ☐ Constraints: gather information on loads and design constraints (such as corrosive atmosphere, fire rating requirements, type of building structure).
- ☐ Select the suspension system
- 2 ☐ Select configuration type: choose spacing and positions of suspension assemblies.
- ☐ Select safety margins and redundancy limits: decide on appropriate safety factors.
- 1 ☐ Select system components: choose suitable components.
- ☐ Risk assessment and design review.

The risk assessment should include an assessment of the hazards posed by the suspended load and the risk to those nearby. The designer should then check that the finished design meets the objectives, and amend it before proceeding with the project.

Some of these steps may need to be reviewed more than once as the design progresses.

Suspension elements

The usual suspension element is a rigid component, usually threaded rod. While this is usually in tension, it also provides some resistance to compressive forces, helping to ensure the rigidity of an installation.

3 An alternative to threaded rod is wire rope-based suspension. While these elements are strong under tension, they provide no resistance to compressive or bending loads. That said, careful design (for example setting wires at angles – see below) can usually provide suitable restraint.

Most threaded rod systems (fixings, threaded rod and associated fittings) are significantly over-specified for most applications, allowing considerable freedom of installation methods. Wire rope systems, on the other hand, tend to be more closely specified against the design load and can be overstressed if incorrectly installed.

Whereas threaded rods are usually mounted vertically, wire rope systems can

Services engineering issues

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easily be installed at an angle. This significantly increases the range of suspension points that can be used. However it has other effects, such as an increased load on fixings, which must be accounted for in the design.

4 Information about the suspended load will be required. For a simple run of services, all that may be needed is the weight per metre and any limits on maximum support spacings. For complex items of plant, the dimensions, weight, centre of gravity, and suspension attachment points may need to be known.

Consideration should be given to the kind of loads that may be applied to the suspension system. Although most loads in building services applications are static, some equipment may create brief dynamic loads, especially during start-up. Pipework, for example, can undergo a shock loading when pumps are suddenly started or stopped.

Other constraints will be the supporting structure and operating environment of the building. The materials and permissible fixing points should be identified. Any environmental constraints should also be identified, such as a corrosive atmosphere. Swimming pool halls, for example, can be very corrosive atmospheres, and require the use of corrosion-resistant hangers.

Load calculations

4 Information on the weight of services to be suspended, such as the weight per metre of items such as pipes and ductwork, should be obtained from manufacturers and system suppliers.

Designers should check that these weights will reflect the loads to be experienced during services operation. This means that the weights of pipework and terminal units, such as fan coils, should not be given in a dry condition but include the weight of water.

Key services watchpoints

- ☐ Before the design of a suspension system can begin, the suspension requirements – and the constraints imposed by the building structure and operating environment – need to be understood by the designer
- ☐ Once a configuration has been selected, the system designer must calculate the loads on each fixing to ensure that suitably strong components are specified and check with the structural engineer that the design loads have not been exceeded
- ☐ Designers should check that the weights given to the structural engineer reflect the actual loads to be experienced during building operation, such as fan coils full of water

Figure 1: A wedge-nut system for fixing services to steel decking. ©Lindapter.

See also

1 Essential fastening issues, page 8
2 Fixing services to structure, page 10
3 Wire rope fixing systems, page 14
4 Table 2, page 9

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The clients' guide to

Structural issues

The responsibility of the structural engineer is not to design, fit and forget. While building services engineers may be very adept at making do with whatever structure is presented to them, and often improvising the suspension systems, true interface engineering means that services and structural engineers must address the critical design issues. Optimising the fixing systems will lead to better and safer design, and a faster and more cost-effective installation.

Figure 2: A Lindapter TR60 services re-entrant attachment to steel decking. ©Lindapter.

Structural perspectives

Decisions made by structural engineers will have significant effects on the installation and performance of the building services. Similarly, the requirements of the building services will have implications for structural design.

Member resistance

In selecting suitable section sizes for the beams and columns, structural engineers need to make an allowance for the weight of the building services. This is true whether the services are suspended directly from the beams or from the floor slabs or secondary members.

Unlike the building services engineer responsible for designing the support system, it is unlikely that the structural designer will know the exact nature or weight of the services to be supported at the time the structure is being designed. Therefore, the design must be based on estimates of the likely services weight, usually based on experience.

Typically a value of 0·5 kN/m^2 is used in design, although higher values might be necessary in heavily-serviced buildings

Deflection

The choice of beam section size is often determined not by the required section capacity or member resistance at the Ultimate Limit State (ULS), but by the need to limit deflections at the Serviceability Limit State (SLS). It is common to specify the maximum permissible deflection due to the imposed (live) load. Deflection limits recommended by *BS 5950-1:2000 Structural use of steelwork in building* are given in Table 1.

Where services are supported by beams, the building services engineer should ensure that the services are able to withstand deflections equal to these limits. It should be noted, however, that the total deflection of the beam might be greater than these limiting values because of the additional deflection caused by the self-weight of the beam and the weight of the concrete slab (the dead load).

Some dead load deflection will occur before the services are installed and it is important for services designers and contractors to recognise that the beams might not be horizontal or at the same level along the length of the building at the time that the buildings services are being installed. In some cases, beams can be pre-cambered to off-set the effects of dead load, but where this is not possible, services should

Services engineering issues

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be supported in a way that allows the levels to be adjusted.

Choice of floor type

1 The use of support systems that fasten to the underside of steel floor decking provide the building services engineer with considerable choice regarding the location of the services and their supports, without the need for costly site activities such as drilling into the concrete slab. However, advantage can only be taken of this convenient means of support if a suitable floor type is chosen.

As this is one of the first decisions taken in the building design process, clients should recognise the importance of including building services engineers in the decision-making process at the earliest possible stage.

Fire protection

In choosing fire protection for the beams, structural designers should take into account the need to install services, particularly in cases where a mechanical connection has to be made to the beam flange.

2 Board fire protection should only be used where contractors are not likely to support services from the beams. The act of cutting away the board to accommodate clamps would compromise the fire protection. With fire
3 retardant blankets or cement-based spray protection systems, a wire rope system can be used to support the services. Again, the direct attachment of clamps to the beam flanges will not be possible.

Intumescent coatings are probably the most favourable fire protection solution where flange clamps are to be used, although care must still be taken to ensure that the fire protection system is not damaged during the
4 installation of the building services.

Key structural watchpoints

- ☐ Structural engineers should alert clients to the importance of including building services engineers in the decision-making process at the earliest possible stage
- ☐ While 0·5 kN/m^2 is often used as a rule of thumb value for the weight of services, a higher value might be necessary for heavily-serviced buildings such as laboratories or industrial buildings
- ☐ The design of the beams is often governed by the maximum permissible deflection due to the imposed (live) load as recommended by *BS 5950-1:2000 Structural Use of Steelwork in Building*
- ☐ In choosing fire protection for beams, structural engineers should consider the options for installing services, particularly where mechanical connections to beam flanges may be required

Table 1: *BS 5950-1: 2000* limits for calculated deflections due to imposed loads.

Category	Deflection limit
Cantilevers	Length/180
Beams carrying plaster or other brittle finish	Span/360
Other beams (except purlins and sheeting rails)	Span/200

See also

1 Figure 5, page 11
2 Figure 14, page 18 (and text)
3 Wire rope fixing systems, page 14
4 Further reading (IEP2)

Further reading on page 20

Standards on page 20

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An introduction to

Essential fastening issues

The choice of fixing will depend on a variety of factors: whether the slab is of lightweight steel or heavyweight concrete, and whether the building is new or being refurbished. Designers will be seeking to provide the simplest and quickest configuration to install, while meeting the requirements for load stability and easy access, as well as any requirement for redundancy should a part of the suspension system fail.

Figure 3: The suspension of different services from the structural steelwork is often improvised by multiple trades passing through the same area. This can create conflict and delays, and increase the costs of the project.

Key design factors

A designer tasked to choose a suspension system will be seeking to reach a compromise between a number of requirements, and there will not be a single correct configuration for any particular suspension requirement.
To assist in choosing a configuration, there are some sources of industry guidance on the suspension of different services such as HVCA
1 *DW144* or the *CIBSE Guide B.*

Once a suspension system has been selected, suitable components will need to be chosen. Components are given a rated safe working load, and in many applications it will be acceptable to design a system that operates at or just slightly below that rating (Table 2).

The integrity of a suspension system and the load to be supported not only depends on the strength of the suspension system, but also on the stiffness and strength of the supported load. Stiff loads will tend to successfully transfer loads to a number of adjacent suspension assemblies, while more flexible loads may only transfer the load to the adjacent suspension assembly.

Producing a redundant system may not simply be a matter of applying suitable safety margins, but may also require extra suspension points, or reinforcement of the load.

For light loads, in the order of 1 kN per anchor point (100 kg vertically suspended load), redundancy can usually be assumed if the load can be transferred to two adjacent fixings in the case of linear systems, or three adjacent fixings in the case of bi-directional systems. For higher loads, a full assessment may be required to take account of the stiffness of the supported structure.

Component load limits

A safe working load (SWL) or working load limit (WLL) will be stated by the supplier as being the maximum load the component or system is capable of handling. This may be calculated in a number of ways, but is typically between a quarter and a fifth of the design ultimate tensile strength. This helps provide a margin for any inconsistencies in installation, and normal degradation of the component over its installed life (Table 2).

All of these ratings may be altered (usually decreased) depending on the application of

Services engineering issues

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the component. Components with a fire rating may have their standard safe working load reduced to ensure they provide adequate strength under extreme conditions. (Certified loading data is available from some fixings manufacturers for different exposure times under conditions of standard fire curves.)

Designers must know the load factors of the components they are intending to have supported, and the conditions in which they are expected to operate. If in doubt, checks should be made with the component supplier.

Table 2: Typical safe working loads for common fixings. ©BSRIA.

	Fixing type	Typical range of safe working loads (kg)	Site tests advised?
2	*Wire rope (capacity relates to diameter)*	10 – 325	
	Toggle end fixing on wire (capacity matches that of wire)	10 – 90	
3	*Open coil attachment M6*	90	
	Open coil attachment M8	150	
	Clamp for steelwork	45 – 300	
	Clips for steelwork	60 – 90	
4	*Powder-actuated fixing to steelwork (10 mm)*	200 (approximate)	✓
	Powder-actuated fixing to concrete (non-drilled)	40 (very approximate)	✓
	Powder-actuated fixing to concrete (pre-drilled)	90 (very approximate)	✓
	Powder-actuated fixing to composite decking	Depends on the concrete type	✓
5	***Drilled fixings into solid concrete (30 N/mm²)***		✓
6	*Socket anchor M6*	200 – 300	
	Socket anchor M8	300 – 400	
	Ceiling hanger	80 – 200	
7	*Rubber expansion anchor*	Depends on the base material	✓
8	*Wedge nuts M10*	200 (approximate)	✓

Key services watchpoints

✓

- ☐ Designers must know the actual loads of components, and the conditions in which they are expected to operate
- ☐ Designers should obtain details of the safe working load or working load limit declared by the supplier as being the maximum load a component or system is capable of handling
- ☐ Designers should be aware that components with a fire rating may have their standard safe working load reduced to ensure they provide adequate strength under extreme conditions

Key structural watchpoint

✓

- ☐ The structural engineer hould ensure that the services load assumed during the design is not subsequently exceeded.

See also

1 Further reading, page 20
2 Wire rope fixing systems, page 14
3 Figure 9, page 14
4 Powder-actuated fastening, page 15
5 Table 3, page 13
6 Figure 8, page 13
7 Figure 7, page 12
8 Figure 5, page 11

Further reading on page 20

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Issues to address when

Fixing services to structure

Contemporary forms of building construction provide building services engineers with many opportunities for supporting the mechanical and electrical services. The choice of attachment point to the structure will depend on a number of factors, including the layout of the structural frame, the type of floor construction used, the size and weight of the services to be supported and their location within the building.

Figure 4: A Slimdek 2 wedge suspension hanger developed for the Corus SlimdekW system. ©Lindapter.

Primary steelwork

Services may be supported directly from the main structural beams either using clamps attached to the bottom flange or wire rope passed round the section. Several types of clamp are available to suit attachment to parallel flanges and tapered flanges. Where necessary, attachments can be made to inclined flanges using a swivel-flange clamp.

Small services, such as cables, may be carried on top of the lower beam flange, held in place by clips. Alternatively, if the building use and finishes permit, cables may be carried on cable trays attached directly to the columns.

The advantage of supporting services directly from primary steelwork is that the weight of the services is usually small compared to the other dead and imposed loads carried by the beams and columns. Consequently, the additional loads can be carried without a significant increase in section size.

1 In most cases, the beams and columns will usually be designed for service loads, whether or not the services are carried directly by the steel members. The loads will be taken by the primary steelwork at some point in the load path.

The disadvantage of supporting the services directly from the primary steelwork is that the locations of supports are restricted to points on the structural grid. Where services run perpendicular to the beams supporting them, the resulting span might exceed the maximum unsupported length for the service duct or pipe.

Secondary steelwork

2 In some cases it may be possible to suspend the services from secondary steelwork such as purlins or side rails. Where purlins are used, the same options exist as for structural beams (wire rope round the section or clamps attached to the flanges).

Special clips are available for attachment to purlin flanges or, where heavy duty support is needed, to the purlin web. Cables may be carried in specially-designed cable trays that fit inside the purlin flange.

Unlike primary structural steelwork, purlins and side rails are made from light gauge steel and are designed to support relatively small loads. Care must therefore be taken to ensure that they are capable of supporting the services

Services engineering issues

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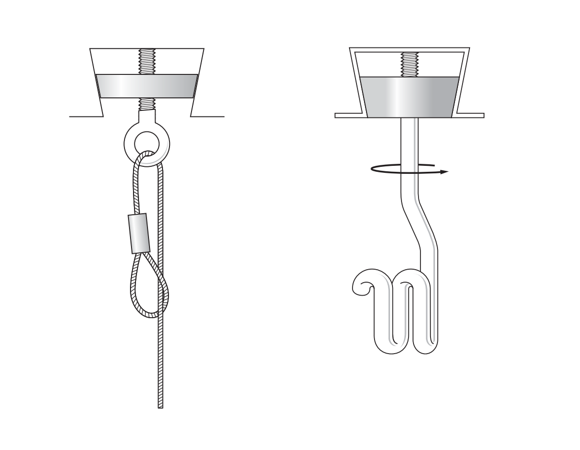

Figure 5, left: An eye adaptor used with a wedge nut. *Right:* a wedge nut and open coil attachment. ©BSRIA.

in addition to the other design loads such as the cladding dead load and the weight of snow. Purlin manufacturers are able to advise on the safe working loads of their products, including service loads.

The advantage of using secondary steelwork is that many more potential attachment points are provided than would be the case with primary steelwork, thereby reducing the span of the services and maximising the options for the building services engineer.

Steel decking

A popular alternative to supporting the services from the primary or secondary steelwork is to hang them from the underside of the steel decking used to form the composite floor slab. Many decking profiles have re-entrant slots into which wedge-shaped mechanical fixings may be inserted, as shown in Figure 5. This simple device is easy to install and will normally have a safe working load of at least 1 kN (depending on the design of the fixing, the steel decking and the gauge of the threaded bar).

Key structural watchpoints

- ☐ Designers should be aware that where services run perpendicular to a beam intended to support them, the resulting span might exceed the maximum unsupported length for the service duct or pipe
- ☐ Structural (and services) designers should check the purlin manufacturers' guidance for safe working loads when using the purlins to support services

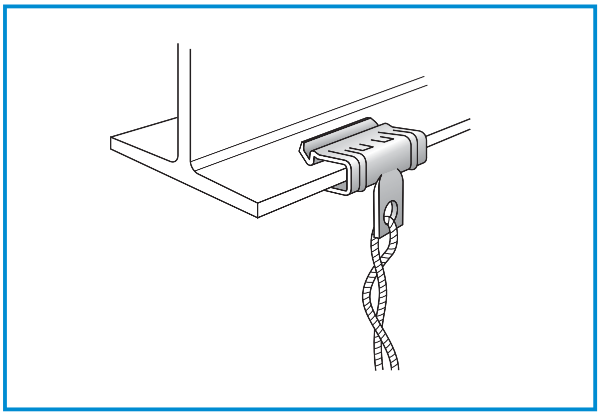

Figure 6: A typical clamp, with integral eye and caddy-type clip, used for supporting light loads. ©BSRIA.

See also

1 Table 1, page 7
2 Wire rope fixing systems, page 14

Further reading on page 20

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Fixing services to structure 2

Special fixings are also available for the Corus Slimdek® flooring system (Figure 4). As with the wedge fixings, the special attachment takes advantage of the re-entrant shape of the profile and is mechanically locked in place to form a strong connection to the decking. A safe working load of 1 kN is quoted by the manufacturers.

The advantage of suspending the services from the decking is that the re-entrant slots are typically only 100-150 mm apart, providing considerable choice regarding the location of the services. Provided that the safe working load of the floor slab is not exceeded, new services can easily be attached at any time over the operating life of the building.

Concrete decking

The major issues for selecting a method of attachment to concrete decking are:

- ☐ The type of structure
- ☐ the base material
- ☐ the applied load
- ☐ the application dimensions
- ☐ temperature ranges
- ☐ the corrosion conditions
- ☐ the attachment configurations.

Table 3 identifies the common fixings for different base materials. Many concrete structures will contain reinforcing bars or pre-stressing bars or cables.

Cutting or damaging these reinforcement elements can significantly affect structural strength. If the reinforcement is hit, the fixing should either be relocated or the reinforcement be cut - but only with the permission of the structural engineer.

1 Drilled fixings may be used with an open coil attachment. M6 and M8 versions require 8 mm and 10 mm hole diameters respectively drilled typically 25 mm and 30 mm deep. They are relatively strong and, due to the shallow embedment depth, should avoid hitting the reinforcement bar.

Voided construction

In voided construction, fixings are not straightforward. Suitable methods include toggle fixings, plug and screw fixings, expanding anchor bolts (Figure 7), and drop rods (the latter for heavy loads). Toggle fixings are designed to penetrate the void. They are usually only suitable for light loads such as light fittings and cable conduits, but not for suspended ceilings.

2 It is vital that the quality of the void is known. If the concrete is weak due to cracks, poor casting or lack of thickness, either the act of drilling into the void will damage the concrete, or it will break under the load.

Hammer-set socket-anchors (also known as drop-in anchors) are used for suspension of services. The anchor is usually set using a punch and club hammer, but some manufacturers offer setting adaptors for use in hammer-drilling machines. These speed up setting and ensure optimum expansion.

Plug and screw and expanding anchor bolts can be inserted into the centre of the rib. It is vital that there is enough space between the reinforcing bars. The concrete around the reinforcement in the ribs can be poorly compacted and may need repairing to provide an adequate anchor (Figure 8).

Drop rods are suitable for heavy loads, and can be fitted through the slab with a fixing plate on top. This is only suitable where a screed covers fixings. As reinforcing bars can be very close they may not provide room for a rod.

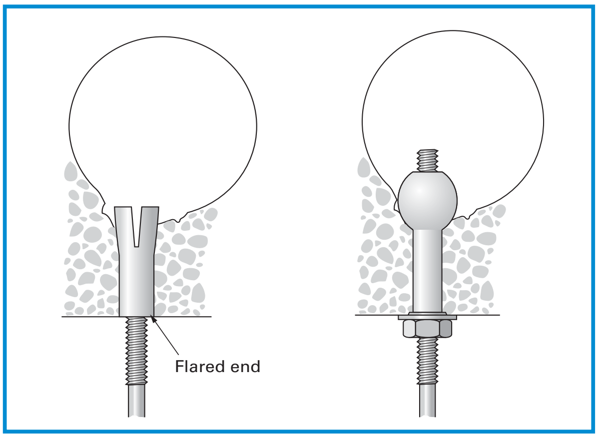
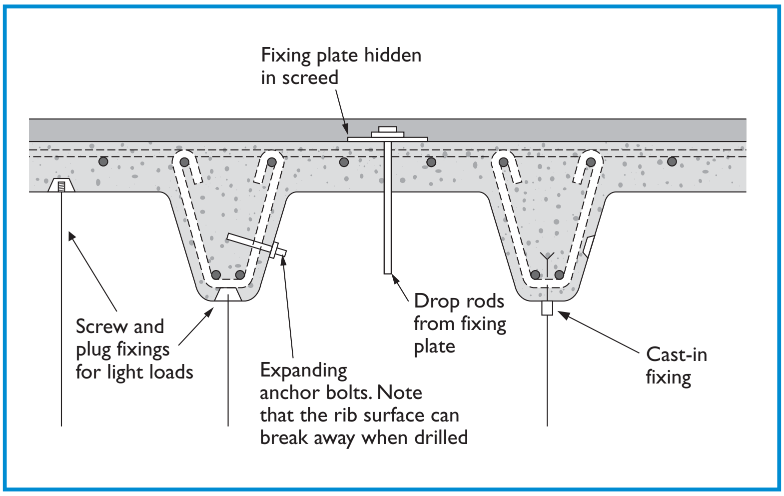


Figure 7: Methods of locating fixings in hollowcore concrete. *Left:* A hammer-set socket anchor, and *right:* a rubber expansion-anchor with a flared end. ©BSRIA.

Services engineering issues

Structural issues



2 ***Figure 8:*** Possible fixings to soffits of exposed ribs. Source: BSRIA.

Table 3: Common fixings for a range of materials. ©BSRIA.

Building structure	Other factors	Suggested fixing types
Exposed steel work	Access to wrap rope around structural element (may be purlin or channel-fixed between sections)	Direct attachment using wire-rope loop (or indirect attachment into channel itself using adaptor)
	No access to wrap rope around structural element	Clamps and clips
		Powder-actuated fixing or special clips
		Toggle inserted through hole drilled in horizontal flange
3 *Solid concrete*	Suitable for powder-actuated fixings (site tests may be required to check)	Powder actuated fixings (pre-drilled in preference to non-drilled)
	Not suitable for powder-actuated fixings (site tests may be required to check)	Drilled-in fixings
2 *Hollowcore concrete*		Drilled fixings – rubber expander or socket anchor with flared end
Profiled roofing	Not open to elements	Toggle inserted through drilled hole
Composite decking	Profile suitable for wedge nuts	Wedge nuts
	Plain profile	Powder-actuated fixing or special clips
		Drilled fixings

Key services watchpoints

- ☐ The cutting or damaging of reinforcement elements can significantly affect structural strength and should therefore only be carried out with the permission of the structural engineer
- ☐ When attempting to penetrate voided construction, it is vital that the quality of the void is known to prevent cracks or breakage during the fixing process
- ☐ When attempting to fix to concrete ribs, the services engineer should seek structural advice on whether the concrete around the reinforcement in the ribs needs repairing to provide an adequate anchor

See also

1 Table 2, page 9
2 Further reading (IEP3 Figure 16) page 22
3 Powder-actuated fastening, page 15

Further reading on page 20

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An introduction to

Innovative fastening methods

Services and structural engineers are no longer limited to the humble threaded rod in order to support or suspend building services. A number of alternative fixing methods are now available that are often faster to install and more cost-effective. However, they all have their strengths and weaknesses, and before deciding on a fixing system services designers should liaise closely with their structural colleagues to identify the most suitable fixing for the particular context.

Wire rope fixing systems

Wire rope suspension is increasingly being used for mounting building services components. There are major advantages of flexible positioning and installation productivity benefits. For example, where threaded rods are usually mounted vertically, wire rope systems can easily be installed at an angle. This significantly increases the range of suspension points that can be used.

The majority of conventional suspension systems have vertical suspension elements, and as such fixings and suspension elements are subjected to purely tensile loads in a vertical direction. One of the advantages of using wire rope systems is that the rope can easily be installed at an angle to allow for different anchor points for fixings. However when taking advantage of this feature, designers must take into account the fact that this will apply shear loads to fixings, and will increase the total load on the fixing and wire (Table 4).

Most wire rope used in the UK will be compliant with *BS 302*. Compliance and test certificates can usually be obtained from the supplier. Alternatively, where the rope is supplied as a component of a suspension system, the supplier may give an overall rating for all the components of the system.

Some way of attaching the wire rope to other pieces of equipment such as fixings or the suspended building services components will be required. This may be through a device or clamp directly gripping the rope, or the rope may be looped to form an eye that may be placed over suitable attachment points.

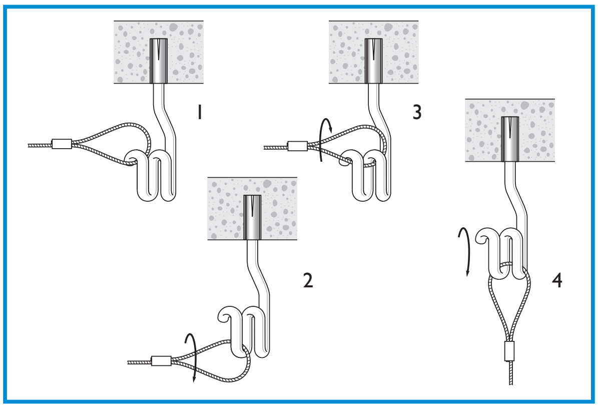
An eye may be formed in a rope in a number of ways, but the most common way is where the ferrule is crimped around the adjacent lengths of rope. The eye may be a soft eye, simply formed by the loop of the rope, or a thimble may be inserted to ensure that the eye is held open and retains its shape. Some fixings may have an integral eye. The free end of the wire is fed through the eye, and then pulled tight through the loop of the rope.

Some wire rope grips intended to be used to form an eye in a rope can be used to join two separate lengths, but if they are not designed for this application then there is a risk of failure. Ideally, a wire rope of the correct length should be obtained, but where this is not possible designers and installers must ensure they are using joining methods approved by the component manufacturer.

Table 4: The effect of wire rope angle on the rope and fixing load. ©BSRIA.

	Loading of each wire and fixing		
Angle from the vertical	*Vertical load in kN*	*Lateral load in kN*	*Total load in kN*
0°	1·00	0·00	1·00
1°	1·00	0·27	1·04
30°	1·00	0·58	1·15
45°	1·00	1·00	1·41
60°	1·00	1·73	2·00

Figure 9: The use of wire ropes with open-coil attachments fitted into structural slabs. ©BSRIA.



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©BSRIA

Figure 10: Powder-actuated fastening (otherwise known as shot firing) is suitable for many types of structural slab.

Powder-actuated fastening

Powder-actuated fastening (sometimes referred to as shot-fired fixing) is a portable system for fastening building services supports to steel, concrete and masonry. The system comprises a nail driven into the base material via a piston that is powered by a small explosive cartridge.

The system combines into a single process the conventional two-stage approach of drilling a hole and then knocking in an anchor.

A range of different nails and connectors are available to suit numerous applications and loads. Irrespective of base structure, the most common technique is to fix a special clip that will have the loop of the wire rope already located in it.

The nature of concrete means that powder-actuated fixings applied without predrilling may not always work, as the aggregates close to the surface are likely to cause deflection of the nails. Pre-drilling using special drill bits usually overcomes this problem.

Site trials are therefore always required in concrete applications. If tests reveal significant problems, then a technique of pre-drilling should be used. Although pre-drilling adds

Key services watchpoints

- ☐ **Wire rope fixings**
  Suspending loads on wire rope at an angle will add shear loads to the wire, and thereby increase the wire's total load
- ☐ Wire ropes can be looped to create an eye, but some rope products are not designed for this application and may fail
- ☐ Designers should obtain compliance and test certificates from suppliers and ensure the installing contractor is aware of wire-rope product limitations
- ☐ **Powder-actuated fixings**
  Designers should specify that all trades required to install powder-actuated fastenings are trained and certified to the appropriate standard of competency
- ☐ Trial fixings are recommended for all new applications to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used

See also

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An introduction to

Innovative fastening methods 2

cost, improved reliability may mean fewer failed fixings.

Pre-drilled or non pre-drilled application techniques require different clips. Trial fixings
1 are recommended for all new applications to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used. When requested, fixing manufacturers will usually assist in trial fixings.

The powder-actuated fastening tool can contain multiple cartridges and fastenings, making fixing a quick and easy process.

1 Powder-actuated fastenings can be used to support a wide range of m&e services including ductwork, fan coil units, electrical tray, luminaires and pipework. The typical load range is between 40-90 kg per fixing.

Time and cost savings

BSRIA has observed that the use of powder-actuated fastenings can reduce installation times by up to 65% in comparison to the more traditional two-stage approach that uses a drilled hole and knock-in anchor.

BSRIA has also found that the use of powder-actuated fastenings can result in a total installed cost saving of 36% per fixing in comparison to the traditional approach. However, powder-actuated fixings are usually viable only where a significant number of fixings is needed.

Approval for powder-actuated fastening must be obtained from the structural engineer. Approval may also be required from the local authority, for example where noise break-out may be a problem.

The benefits of these devices can be fully realised when a design team uses installation drawings with common levels. This will simplify the process of setting-out, particularly if infra-red setting-out devices are used to locate the fixing points.

Adhesive fasteners

1 Adhesive fasteners for building services supports can remove the need to drill or shot-fire fixings into the structure. Once the surface has been primed, the adhesive pad can be fixed quickly and easily to steel, concrete, glass, and most surfaces provided they are flat, smooth, dry and clean. Adhesive fasteners have a safe working load from 5-15 kg.

Figure 11: adhesive fasteners are ideal for supporting lightweight services. ©BSRIA.

The system is quick, quiet and easy to install using purpose-designed application tools. An extension pole can also be used to fix the supports to the slab without climbing ladders. Surface bonding of the adhesive fasteners avoids the need for structural penetration.

Adhesive fasteners are ideal for supporting general, lightweight services including small diameter pipework up to 50 mm, conduit and electrical data to 20-25 mm, and fire cables up to 30 mm. Adhesive fasteners are limited to loads of up to 15 kg per fixing. Designers should check that the use of adhesive fasteners are approved by all relevant project parties.

Time and cost savings

2 BSRIA has observed that the use of adhesive fasteners can reduce installation times by up to 47% in comparison to the more traditional approach that uses a drilled hole with inserted plastic plug and screw. BSRIA has also calculated that the use of adhesive fasteners can result in a total installed cost saving of 31% in comparison to the traditional approach.

The performance of this product is largely independent of operator skill and minimal training is required. Adhesive fasteners are not suitable for use on painted or plasterboard surfaces.

Figure 12: The Hilti MQ modular channel system is designed to speed up the installation of supports for m&e services.

Channel support systems

Channel support systems are designed to speed up the installation of supports for m&e services. BSRIA has studied the benefits of two such systems and identified their virtues and shortcomings.

The Hilti MQ channel system

2 BSRIA studied the site application of the Hilti MQ channel installation in 2002. BSRIA found that such systems are simple to use, especially if the installer has prior knowledge of a traditional channel system.

Channel connections are made using a quarter turn push-button channel nut, which is a single component and does not require a bolt and back nut. Different sizes of channel are available, and the Hilti system comes in single channel sizes from 21-72 mm, and 41 mm double-channel profiles ranging from 41·2-124 mm.

A pipe-ring saddle can be installed onto a piece of channel without the need for tools. The saddle is attached to the channel with a quarter turn, and then slid along to the correct location. The threaded rod is then inserted and the locknut tightened by hand. It is important that the designer selects the correct size of component to avoid under-engineering.

Time and cost savings

Compared to traditional channel systems and fittings, the rapid installation system can take

Key services watchpoints

- ☐ **Powder-actuated fixings**
  Trial fixings are recommended to ensure the particular application is feasible and the correct fastener shank length and strength of cartridge are used
- ☐ The cartridge and nail type must be correct for the base material, as the use of a powder-actuated fastening to the underside of a concrete slab with a high aggregate content may cause spalling
- ☐ Approval for powder-actuated fastening must be obtained from the structural engineer and also from the local authority where noise break-out may be a problem
- ☐ **Adhesive fasteners**
  Adhesive fasteners are limited to loads of up to 15 kg per fixing. Designers should check that the use of adhesive fasteners are approved by the project parties

See also

1 Table 2, page 9
2 BSRIA site feedback data (not yet published)

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Innovative fastening methods *3*

Left: figure 13: Halfen channel laid out prior to a concrete pour. ***Below, figure 14:*** A drop-rod fitted to the Halfen channel. Note the thermal insulation.

54% of the intallation time. There can also be a reduction in the number of fixing components required. Disassembly of installed support systems is also more rapid than traditional systems - important if changes are likely to be needed later.

The double-channel profiles can replace heavy-duty welded support systems, and eliminate hot works operations on site.

Cast-in channel systems

Cast-in channel is a system that involves steel channel being cast into concrete floor slabs in order to provide in-built support for services and architectural systems.

Items can be secured to a slab significantly faster with integrated cast-in channel than a plain concrete slab. The key criteria are the extent of the area to be covered by the support mechanisms, and the spacing required between parallel channel lengths.

Time and cost savings: Halfen channel

2 BSRIA site research carried out in 2003 has shown that the unit time taken to fix a drop rod assembly to cast-in Halfen channel is 2·5 minutes. By contrast, the time taken to measure and mark a fixing point, drill a hole, insert an anchor and fix a drop-rod assembly into a plain concrete slab was measured at 5·5 minutes.

At an installed cost of £11.40 per linear metre (at 2003 prices), the investment in cast-in channel needs to be off-set by cost and time savings by services and architectural trades. This means early input by the services contractors that wish to use cast-in channel in order to determine the support requirements.

The services and architectural trades who use the channel system also need to demonstrate time and cost savings when preparing budgets and cost programmes. If this is not done, the integration of cast-in channel will increase concrete slab costs without necessarily creating downstream savings. Likewise, if insulation has to be fitted to the underside of the slab after the channel has been cost-in, thereby concealing the channel, then installation savings will not necessarily accrue (Figure 14 above).

Sheet metal brackets

Another innovative method of supporting services from slabs involves a non-proprietary method of using sheet-metal brackets. Such brackets can be installed by the pipework contractor to speed up the installation of branch pipework.

The brackets are pre-drilled to receive the pipe hanger drop rods. This can greatly simplify the installation process for the mechanical contractor because it eliminates the need to measure, mark, drill and fix anchors in the ceiling slab.

Figure 15: Chilled water pipework suspended from a sheet-metal bracket installed by a ceiling contractor.

Co-ordination is needed between different work packages in order to deliver an integrated approach. If this is achieved, then savings can be generated in the number of different trade visits to work areas, installation time benefits and a reduction in the number of anchors installed in reinforced concrete slabs.

Polymer pipe clips

Polymer pipe clips are easy to release and re-locate, and are available in a wide range of sizes in imperial and metric measures. They can also be easily adjusted. They are also designed to clamp around insulation, enabling a continuous vapour seal.

Designers need to choose the appropriate clip suitable for solid or insulated pipework.

Time and cost savings

During site research carried out in 2000, BSRIA found that polymer pipe clips were relatively quick to install, taking typically 44% of the time needed for a conventional fitting. They can also cost less than a conventional fitting, typically 10-15% cheaper.

2 Polymer clips tested by BSRIA gave perpendicular pull-test results in excess of 150 kg. The slip tests gave results in excess of 29 kg. On the stud clip, the pull tests gave results in excess of 26 kg and the slip tests gave results in excess of 15 kg.

Key services watchpoints

✔

- ☐ **Cast-in channel**
Services and structural engineers need to identify the extent of the area to be covered by the support mechanisms, and the spacing required between parallel channel lengths

- ☐ Design teams need to ensure that the investment in cast-in channel is off-set by cost and time savings by services and architectural trades

- ☐ Services and architectural trades who use the channel system also need to demonstrate time and cost savings when preparing budgets and cost programmes

- ☐ **Sheet metal brackets**
Good co-ordination is needed between structural and services contractors in order to deliver an integrated approach to the design and installation of supports

Figure 16: Polymer pipe clips are easy to release and re-locate, and are designed to clamp around insulation.

See also

1 Table 2, page 9
2 BSRIA site feedback data (not yet published)

Further reading on page 20

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Further reading

Designers and contractors should always follow the guidance laid down in prevailing standards.

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Standards

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BS 2092 Grade 1 for Drilling or for Fixing Powder Actuated Fastenings

BS 302-1:1987 Stranded Steel Wire Ropes. Part 1: Specification for General Requirements, British Standards Institution, 1987

BS 302-2:1987, Stranded Steel Wire Ropes. Part 2: Specification for Ropes for General Purposes

*Note that this list is not comprehensive. A great deal of additional information may be obtained from manufacturers and from industry bodies such as the Construction Fixings Association.

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*Note that this list is not comprehensive. A great deal of additional information may be obtained from manufacturers, including Lindapter (www.lindapter.com).

Glossary

Building services terms

Fan coil unit	A device often fitted in the ceiling void and which comprises a fan, heating and/or cooling coil, and an air filter, all housed in a metal casing. The fan-coil unit may be supplied with fresh air from the main air supply ductwork.
Cable tray	Horizontal tray, usually of metal, used to carry power cables and voice and data cables above a suspended ceiling (also underneath a raised floor). Cables may be segregated over two or more trays to prevent electrical interference. Cable tray is commonly suspended from the soffit or from other plant items such as ductwork.
Busbar	A low voltage power cable usually run beneath raised floors or above suspended ceilings, with fittings that enable take-offs to electrical services such as lighting and air conditioning equipment.
Luminaires	A light fitting inclusive of lamp and control gear, housed within a suspended ceiling. Luminaires are often part of an integrated services module comprising fire detectors, public address speakers, motion sensors and acoustic panels. They will be heavier as a consequence.

Structural terms

Composite floor slab	A floor consisting of profiled steel decking and *in-situ* concrete. The two elements act together structurally.
Flange	The projecting element at the top and bottom of an I beam.
Intumescent coating	A coating applied to steel beams or columns that expands to many times its initial thickness when heated, thus providing an insulating layer to the steel.
Primary steelwork	The main structural frame comprising beams and columns.
Purlin	A horizontal beam in a roof, usually made from light gauge steel, which spans between the rafters and supports the roof cladding.
Secondary steelwork	Smaller steel members which transfer loads from the cladding (roof or wall) to the main structural frame.
Serviceability Limit State (SLS)	The point beyond which the specified service criteria are no longer met.
Steel decking	Profiled light gauge galvanised steel sheet which supports the wet concrete during construction and acts compositely with the concrete in service.
Ultimate Limit State (ULS)	The point beyond which the structure would fail.