5. Services design

5.1 Services integration

There are three opportunities for service integration using Slimdek:

- Partial integration: pass major services below the slab and beams and use the space between the ribs for small pipes and fitments, such as lighting units. This allows for cross-overs of ducts or pipes. The elimination of downstands provides for greater flexibility of service distribution and reduces the depth of the structure-services zone.
- Full integration: form circular or elongated openings in the webs of the ASB so that ducts and pipes located between and within the depth of the ribs can pass through the beams. (Alternatively, the space between the ribs can act as a duct in itself, which again continues through the openings in the beams).
- Slab penetrations: Slimdek offers the services engineer flexibility in the provision of service openings within the floor slab. However, careful co-ordination with the structural engineer is required so that openings can be provided without any, or with minimal, additional strengthening. See also *Section 2.2.6.*

The ComFlor 225 decking has a re-entrant portion in the crest of its profile that can provide a suspension point for services and ceilings without need for additional fixings, *see Section 5.4.*

In certain areas where spans are relatively short (< 3.5m), shallower floors may be created locally, using a composite slab of 120 to 150mm depth comprising more traditional decking of 50 to 60mm depth. This is particularly useful in, or adjacent to, core areas where duct cross-overs and horizontal bends are required without deepening the ceiling-floor zone excessively.

5.2 Openings

5.2.1 Openings in ASB sections

Full integration of services can be achieved by providing openings through the ASB midway between the ribs of the deep decking. During fabrication, an opening (usually circular or oval) is cut in the web of the ASB. The same sized openings are also cut in the diaphragms that fit between the ribs and a sleeve is placed through the beam and diaphragms before the concrete is placed. The elements that form the opening in an ASB are shown in *Figure 5.1.* Flat, oval or circular ducts may be placed inside the sleeve and sealed externally.

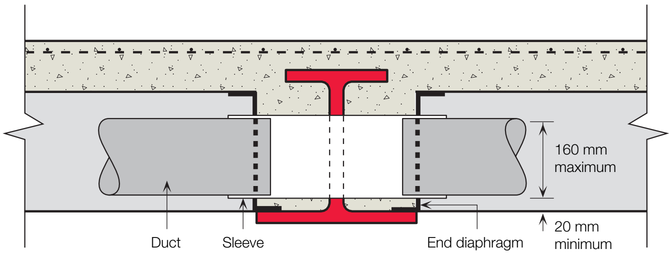


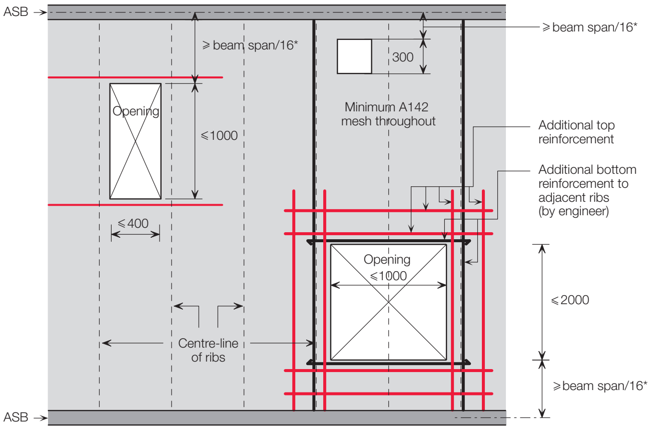
Figure 5.1 Forming openings through ASB

5.2.2 Maximum sizes of openings

Information on the size of openings that can be formed in an ASB is given in *Section 2.3.3.6.*

5.2.3 Openings in the slab

Generally, openings can be introduced without significant limitations as shown in *Figure 5.2.* Structural requirements around openings are given in *Section 2*.

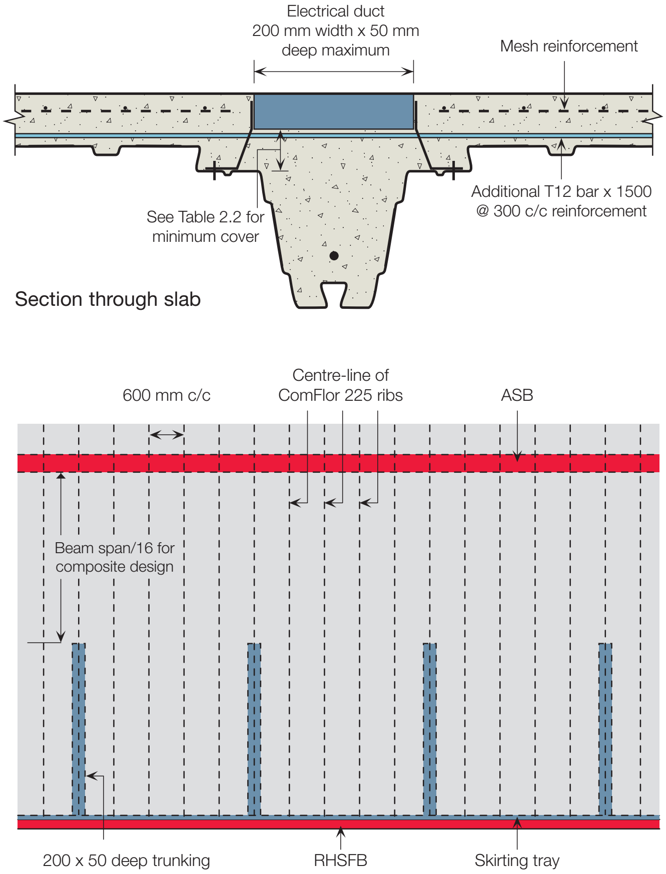


** for composite beam design*

Figure 5.2 Details of openings in the slab

5.3 Electrical trunking and ducts

It is also possible to create routes for electrical trunking and ducts which can be located either within the structural slab or within a structural or non-structural screed, see *Figure 5.3.* Further information is given in *Section 2.2.7.*



Section through slab

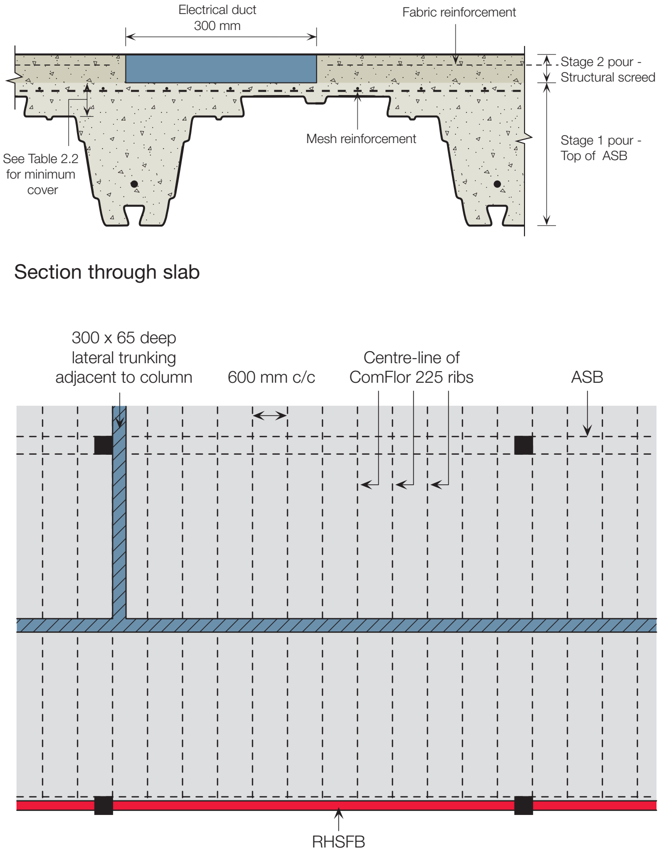
Figure 5.3 Electrical duct within composite slab

5.4 Service attachments

The ComFlor 225 decking makes the fixing of services and ceilings much easier. Service hangars can be suspended from the crest dovetail and utilised for services running parallel or perpendicular to the deck span. In addition, ceiling systems may be hung from the top crest hanger or attached directly to the underside of the rib using self-drilling self-tapping screws after the concrete has been placed.

The adjustable Lindapter Slimdek 2 fixing, *see Figure 5.5,* is designed for use with ComFlor 225 to accommodate variances encountered on site and enable secure suspension of services directly from the underside of the ComFlor 225 composite floor decking. It clips into the crest dovetail of the decking and achieves a safe working load of 1.0kN per fixing with a built-in factor-of-safety of 3. Minimum spacing of crest fixings is 500mm at full working load provided the overall design load for the slab is not compromised. Installation of Lindapter Slimdek 2 is fast and accurate every time and is carried out without specialist tools or skills because the product slots easily into the re-entrant channel and is locked mechanically with a 180° turn of a spanner. Variable drop rod position and lateral adjustability along the re-entrant channel permit unhindered alignment of service runs, whilst the shallow fixing depth enables pipework, ducting, electrical equipment and cable trays to run within the structural floor space.

Alternatively self-drilling self-tapping screws may be used to attach hangers to the decking after the concrete has been placed. Care must be taken not to compromise the integrity of the decking and the use of non-percussive equipment is advised.



Section through slab

Figure 5.4 Electrical duct within structural screed (second stage pour)

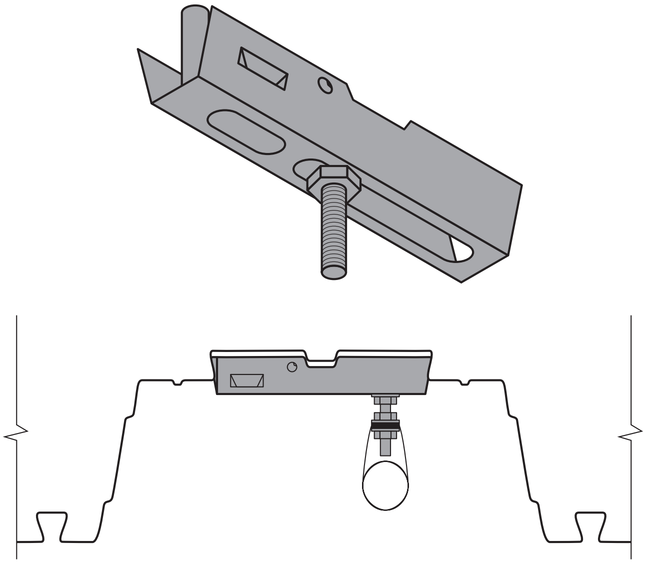


Figure 5.5 Lindapter Slimdek 2 fixing

5.5 Advanced energy efficient systems

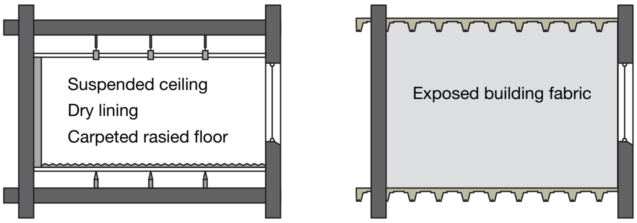
The Slimdek system can be designed to incorporate the latest technology in energy efficient services principles. Research and development into enhanced forms of passive service systems and optimising the contribution of the structure to the operation of the building environment have led to new methods of air distribution on and through the floor construction.

Enhanced systems may be created through the use of a combination of suspended ceilings, raised floor voids and supply and extract ventilation. Some of these systems are described in the SCI-P-181: *Environmental Floor Systems*[20], and in SCI-P-273: *Service Integration in Slimdek*[24].

For applications where increased cooling capacity is necessary, radiant cooling ceiling panels (chilled ceilings and beams) can be integrated into Slimdek construction. The above SCI publications give more detail and a worked example of the use of chilled beam systems.

5.5.1 Fabric energy storage

Floor slabs provide for regulation of internal temperatures by their thermal capacity which may be used to control ambient heat gains within a building. Surface finishes such as raised floors or direct finishes such as carpets generally restrict the efficient transfer of heat between the space and the top surface of the floor slab as shown in *Figure 5.6(a).* However, the underside of the floor slab is considered an ideal surface to utilise the inherent thermal capacity of the slab, provided the ceiling is designed not to impede this action as shown in Figure 5.6(b). This technique can reduce internal temperatures by 2 to 3°C, which is equivalent to a cooling effect of approximately 20W/m^{2}°C. If advantage can be taken of the energy storage capabilities of the floor slab, then the need for air conditioning may be reduced or, in some cases, eliminated, which will generate considerable savings in capital and running costs.



a) Poor

b) Good

Figure 5.6 Fabric thermal regulation

In a typical building, with diurnal temperature variation, only a relatively thin depth of concrete (typically 75mm to 100mm) is effective for efficient heat transfer and storage to take place. For depths of 100mm and over, no more heat is stored in the slab. The thermal admittance to concrete slabs is shown in *Figure 5.7.* The high surface area of the ComFlor 225 decking used for Slimdek is ideally suited for this daily heat transfer.

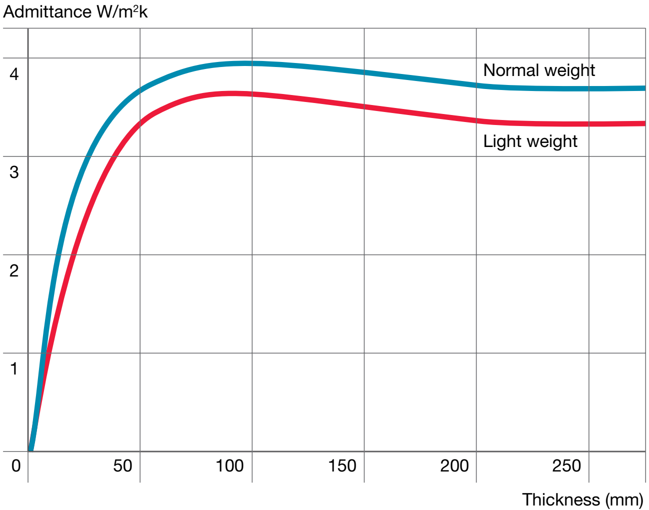


Figure 5.7 Thermal admittance to concrete slabs

In the daytime, heat is generated by the activities within the building, and by the external conditions and solar gain (depending on the fenestration and shading). At night, heat is lost from the building as temperatures fall externally. There is often a need to cool the internal environment during the summer, whilst in winter additional heat may be needed for comfort of the occupants. A typical summer day/night temperature cycle is shown in *Figure 5.8.* Studies show that, in a typical modern office building, equilibrium is reached with the external environment at around zero degrees Celsius. Thus the main requirement is for cooling.

Harnessing the fabric energy storage (FES) potential of Slimdek during the day will reduce the maximum air temperature, whilst at night the heat stored in the slab can be released through ventilation via external louvres.

For passive cooling, it is necessary to expose the soffit of the slab, and the ComFlor 225 decking and bottom flange of the supporting beam ensure good radiative heat transfer. The high surface area of the ComFlor 225 decking provides a 20% better heat transfer than an exposed flat soffit whilst minimising the weight of the floor slab. Where soffits are required to have an improved architectural visual appearance, careful attention to detailing the decking and fixing of fasteners is required. Alternatively, where it is necessary to conceal the slab from below for aesthetic reasons, a perforated ceiling as described in *Section 5.6* may be used.

As with all passive design strategies, success relies upon careful design and implementation as part of an overall low energy philosophy in which heat gain reduction and effective ventilation play key roles.

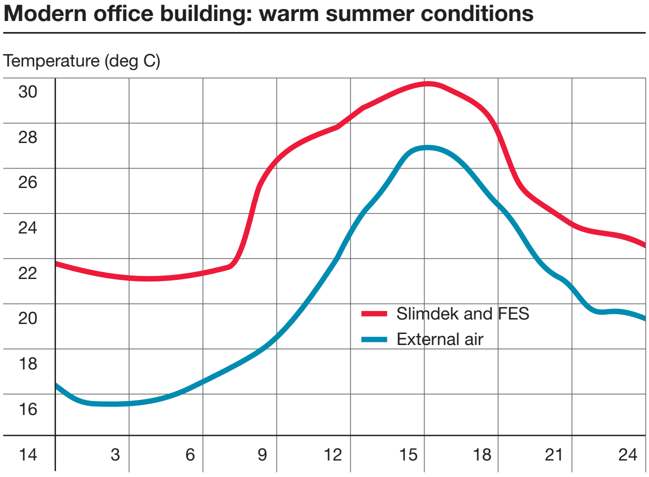


Figure 5.8 Day/night cooling/heating cycle

5.5.2 Integrated services between the ribs

The space between the ribs may be used as ducts for natural ventilation to internal zones as shown in *Figure 5.9.*

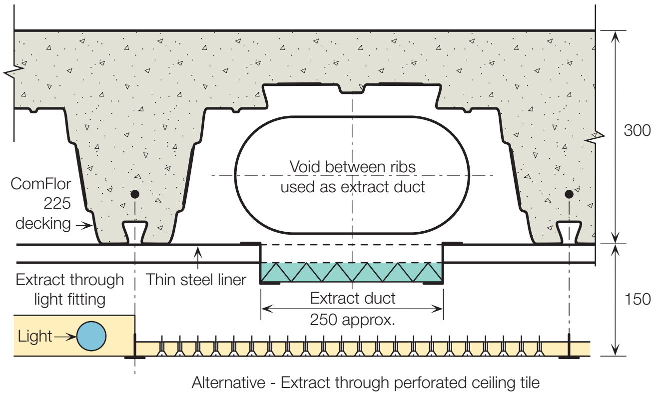


Figure 5.9 Use of space between ComFlor 225 ribs for service duct

In some advanced systems of service integration, it is possible to use the space between the deck ribs as a duct for mechanical ventilation to internal zones of the building as shown in *Figure 5.10.* These details are covered in the SCI publication *'Service Integration in Slimdek'* (SCI-P-273)[24].

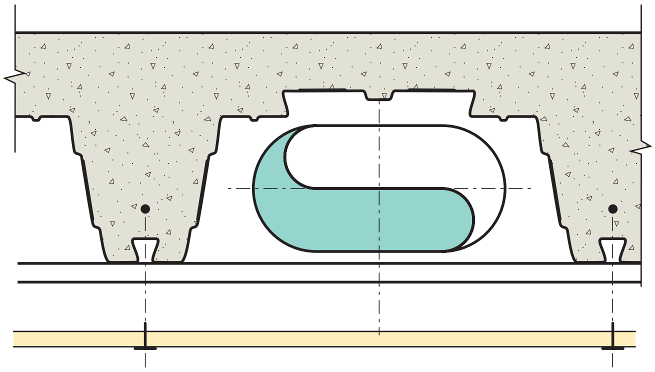


Figure 5.10 Ventilation duct to internal zones

5.6 Perforated ceilings

Perforated ceilings may be used, and tests have shown that ceilings with perforations of approximately 20% of the surface area allowed 85% of the cooling effect of a fully exposed soffit to be achieved by creating sufficient air movement through the ceiling. Thin tiles (preferably metallic) should be used because they present the least resistance to air flow.

Tests have been carried out at The Steel Construction Institute to assess the effect of different ceiling configurations on the passive cooling performance of composite slabs. A test room was monitored over twenty-four-hour cycles when subjected to heat gains replicating a typical office. The major findings are summarised below.

- Conventional closed suspended ceilings reduce the cooling effect of a floor slab by at least 70%.
- Open areas greater than 22% fail to conceal the soffit fully unless the decking and any services are painted in dark colours.
- Thin steel tiles (0.7mm) should be used because they present the least resistance to air flow and allow significant radiative heat transfer to and from the soffit. Mineral board tiles are thicker, providing more resistance to air flow and reduced radiative heat transfer. They are also less robust and are liable to shed material when handled or cleaned.
- Tiles with an open area of 20% allowed about 50% of the air to flow through to the ceiling void under test room conditions when compared with an exposed slab. However, the tiles attain a temperature close to the air temperature at that height, and radiate this heat to the slab during occupied hours. Thus, although convective heat transfer is reduced, radiative heat transfer is increased, resulting in overall heat transfer close to that achieved by a fully exposed slab.
- In test room conditions, perforated ceilings of 15% and 20% open area respectively allowed 81% and 86% of the cooling effect to be achieved, based upon measurements of the soffit heat flux.

The Slimdek profile has been designed to be compatible with the standard 600mm square ceiling tile available from most manufacturers. Perforated steel tiles are usually equipped with a backing of acoustic fleece to moderate the acoustic environment in offices, particularly to reduce reverberation time and enhance acoustic privacy. These tiles can be supplied without the backing so as to be open to allow air to flow through. If possible, the larger hole sizes should be chosen because these have a lower air flow resistance for a given open area. Typical perforation patterns available are shown in *Table 5.1.*

Table 5.1 Typical patterns in perforated ceiling tiles

Open area	Perforation size	Pitch
14%	2.4mm diameter	Diagonal
16%	2.5mm diameter	5.5mm square
20%	1.8mm diameter	3.6mm square
22%	1.5mm diameter	Diagonal
22%	3.0mm diameter	Diagonal

Acoustic performance must be considered when passive fabric thermal storage is used. The exposure of hard reflective slab surfaces can lead to unacceptably long reverberation times and lack of acoustic privacy. With the use of perforated tiles, however, the problem can be more easily overcome, either by use of acoustic absorbent batts suspended in the troughs or by including some tiles with acoustic backing at intervals. The main open areas should always be concentrated near the façade and at the opposite wall because the dominant convection currents during the day will facilitate flow through the ceiling void with this configuration. The overall effect should remain uniform when viewed from below.

The soffit finish will affect the performance. The standard galvanised finish of the soffit will have an emissivity of around 0.3, a value which is significantly lower than that of most building materials (0.8–0.9). Radiative heat transfer can be improved significantly by painting the soffit. Most standard paint finishes will raise the emissivity to 0.8 or above and at the longer wavelengths, the chosen colour has little effect.