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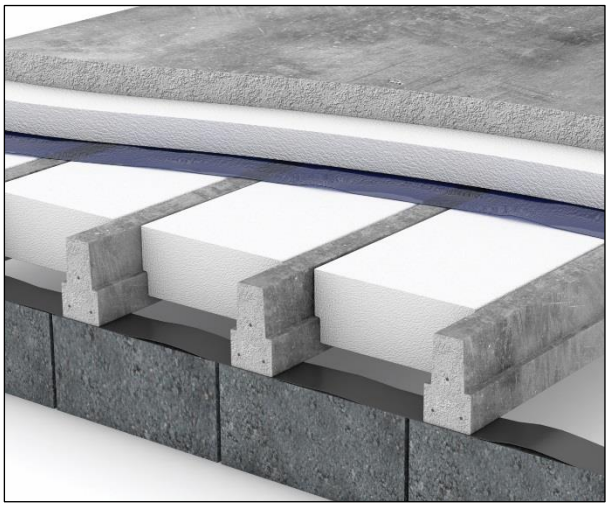
Agrément Certificate
16/5360
Product Sheet 1

RACKHAM FLOOR SYSTEMS

RACKHAM TS SYSTEM

This Agrément Certificate Product Sheet(1) relates to the Rackham TS System, comprising precast, pre-stressed concrete beams, a range of expanded polystyrene (EPS) infill panels, EPS top sheets, and concrete perimeter slip-bricks and closure blocks. The system is for use in conjunction with a structural concrete topping in suspended concrete ground floors for single-family dwellings.

(1) Hereinafter referred to as 'Certificate'.



CERTIFICATION INCLUDES:

- factors relating to compliance with Building Regulations where applicable
- factors relating to additional non-regulatory information where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.

KEY FACTORS ASSESSED

Strength and stability — the system has adequate strength and stiffness to support a suitable structural concrete topping and can sustain and transmit dead and imposed floor loads to the supporting structure (see section 6).

Thermal performance — the EPS top sheets and infill panel components can enable a floor to meet the design U values specified in the national Building Regulations (see section 7).

Condensation risk — the system can contribute to limiting the risk of interstitial and surface condensation; the risk of condensation will depend on the construction and location (see section 8).

Durability — the system components have adequate durability for the design life of the building (see section 10).

The BBA has awarded this Certificate to the company named above for the system described herein. This system has been assessed by the BBA as being fit for its intended use provided it is installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément

Date of Second issue: 8 Jan 2019

Originally certificated on 7 November 2016

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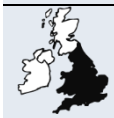
Regulations

In the opinion of the BBA, the Rackham TS System, if installed, used and maintained in accordance with this Certificate, can satisfy or contribute to satisfying the relevant requirements of the following Building Regulations (the presence of a UK map indicates that the subject is related to the Building Regulations in the region or regions of the UK depicted):



The Building Regulations 2010 (England and Wales) (as amended)

Requirement:	**A1**	**Loading**
Comment:		The system can sustain and transmit dead and imposed floor loads to the supporting structure. See sections 6.2, 6.3 and 6.7 to 6.20 of this Certificate.
Requirement:	**C2(c)**	**Resistance to moisture**
Comment:		The system can contribute to limiting the risk of condensation. See sections 8.1 and 8.4 of this Certificate.
Requirement:	**L1(a)(i)**	**Conservation of fuel and power**
Comment:		The system can contribute to satisfying this Requirement. See section 7.3 of this Certificate.
Regulation:	**7**	**Materials and workmanship (applicable to Wales only)**
Regulation:	**7(1)**	**Materials and workmanship (applicable to England only)**
Comment:		The system is acceptable. See section 10 and the *Installation* part of this Certificate.
Regulation:	**26**	**CO_2 emission rates for new buildings**
Regulation:	**26A**	**Fabric energy efficiency rates for new dwellings (applicable to England only)**
Regulation:	**26A**	**Primary energy consumption rates for new buildings (applicable to Wales only)**
Regulation:	**26B**	**Fabric performance values for new dwellings (applicable to Wales only)**
Comment:		The system can contribute to satisfying these Regulations. See section 7.3 of this Certificate.

The Building (Scotland) Regulations 2004 (as amended)

Regulation:	**8(1)**	**Durability, workmanship and fitness of materials**
Comment:		The system can contribute to a construction satisfying this Regulation. See section 10 and the *Installation* part of this Certificate.
Regulation:	**9**	**Building standards applicable to construction**
Standard:	1.1(a)(b)	Structure
Comment:		The system can sustain and transmit dead and imposed floor loads to the supporting structure, with reference to clause 1.1.1(1). See sections 6.2, 6.3 and 6.7 to 6.20 of this Certificate.
Standard:	3.15	Condensation
Comment:		The system can contribute to limiting the risk of surface and interstitial condensation, with reference to clauses 3.15.1(1), 3.15.4(1) and 3.15.5(1). See sections 8.1 and 8.5 of this Certificate.
Standard:	6.1(b)	Carbon dioxide emissions
Comment:		The system can contribute to satisfying this Standard with reference to clauses 6.1.1(1) and 6.1.6(1). See section 7.3 of this Certificate.
Standard:	6.2	Building insulation envelope
Comment:		The system can contribute to satisfying the requirements of this Standard, with reference to clauses 6.2.1(1) and 6.2.3(1). See section 7.3 of this Certificate.

Standard:	7.1(a)	Statement of sustainability
Comment:		The system can contribute to satisfying the relevant requirements of Regulation 9, Standards 1 to 6, and therefore will contribute to a construction meeting the bronze level of sustainability as defined in this Standard. In addition, the system can contribute to a construction meeting a higher level of sustainability as defined in this Standard with reference to clauses 7.1.4(1) [Aspect(1) and 2(1)], 7.1.6(1) [Aspect(1) and 2(1)] and 7.1.7(1) [Aspect(1)]. See section 7.3 of this Certificate. (1) Technical Handbook (Domestic).

The Building Regulations (Northern Ireland) 2012 (as amended)

Regulation:	**23(a)(i) (iii)(b)**	**Fitness of materials and workmanship**
Comment:		The system is acceptable. See section 10 and the *Installation* part of this Certificate.
Regulation:	**29**	**Condensation**
Comment:		The system can contribute to limiting the risk of interstitial condensation. See section 8.1 of this Certificate.
Regulation:	**30**	**Stability**
Comment:		The system can sustain and transmit dead and imposed floor loads to the supporting structure. See sections 6.2, 6.3 and 6.7 to 6.20 of this Certificate.
Regulation:	**39(a)(i)**	**Conservation measures**
Regulation:	**40(2)**	**Target carbon dioxide emission rate**
Comment:		The system can contribute to satisfying these Regulations. See section 7.3 of this Certificate.

Construction (Design and Management) Regulations 2015
Construction (Design and Management) Regulations (Northern Ireland) 2016

Information in this Certificate may assist the client, designer (including Principal Designer) and contractor (including Principal Contractor) to address their obligations under these Regulations.

See sections: 1 *Description* (1.2), 3 *Delivery and site handling* (3.2 and 3.5), 6 *Strength and Stability (*6.3, 6.4 and 6.6*),* 12 *General* (12.2) and 14 *Procedure (*14.1, 14.4 and 14.7).

Additional Information

NHBC Standards 2019

In the opinion of the BBA, the Rackham TS System with concrete toppings reinforced with macro-polymer(1) fibres or steel mesh, if installed, used and maintained in accordance with this Certificate, can satisfy or contribute to satisfying the relevant requirements in relation to *NHBC Standards*, Chapter 5.2 *Suspended ground floors*.

(1) NHBC do not accept micro-polymer-fibre structural concrete toppings.

CE marking

The Certificate holder has taken the responsibility of CE marking the following system components in accordance with the relevant harmonised European Standard:

- the EPS TS infill panels and top sheets, in accordance with BS EN 15037-4 : 2010 and BS EN 13163 : 2012
- the pre-stressed precast concrete beams, in accordance with BS EN 15037-1 : 2008

1 Description

1.1 The Rackham TS System consists of precast, pre-stressed concrete beams; EPS infill panels and top sheets; concrete perimeter slip-bricks and closure blocks; and structural concrete topping for suspended ground floors (see Figure 4 for construction detail).

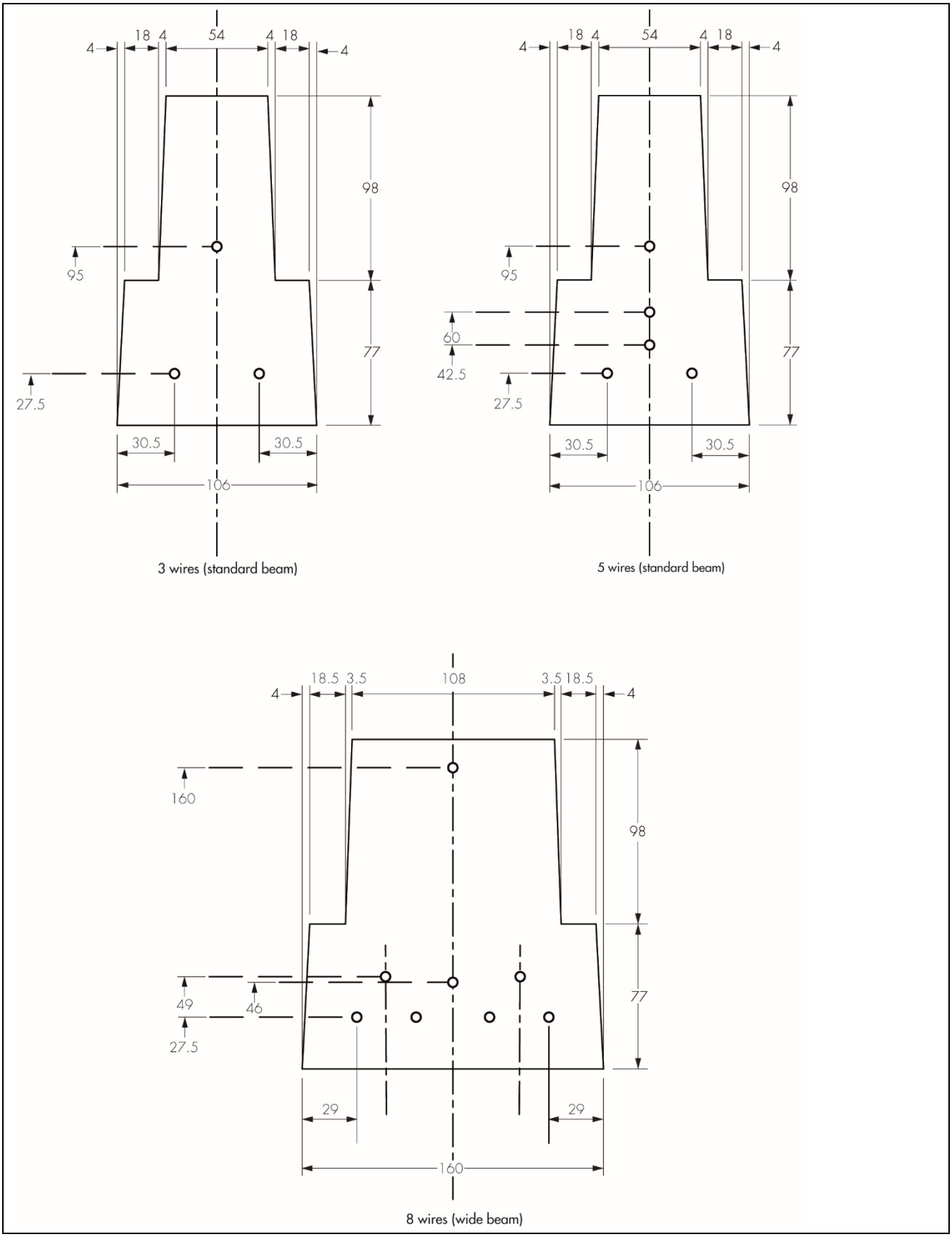
1.2 The pre-stressed concrete beams are available in three types, with the dimensions and characteristics shown in Table 1 and Figure 1. The beams are designed in accordance with BS EN 15037-1 : 2008, BS EN 1992-1-1 : 2004 and its UK National Annex, BS EN 206 : 2013, BS 8500-1 : 2015 and BS 8500-2 : 2015 (see sections 6.16 to 6.20 of this Certificate).

Table 1 Pre-stressed concrete beam properties

Characteristic (units)	**Beam type**		
	Standard 3-wire	**Standard 5-wire**	**Wide 8-wire**
Height (mm)	175	175	175
Top width (mm)	54	54	108
Bottom width (mm)	106	106	160
Number of 5 mm diameter steel wires	3	5	8
Service bending moment resistance (kN·m)	5.560	7.219	12.024
Ultimate bending moment resistance (kN·m)	7.730	11.649	22.078
Shear resistance (kN)	18.462	20.799	39.843
Minimum tensile strength of pre-stressing wire(1) $N \cdot mm^{-2}$	1770		
Minimum characteristic tensile 0.1% proof-stress ($f_{p0,1K}$) of pre-stressing wire(1) $N \cdot mm^{-2}$	1556		
Minimum concrete strength at 28 days	C50 (cylinder)/C60 (cube)		
Beam mass ($kg \cdot m^{-1}$)	34	34	56

(1) The indented pre-stressing steel wire must be in accordance with BS 5896 : 2012.

Figure 1 Pre-stressed concrete beams



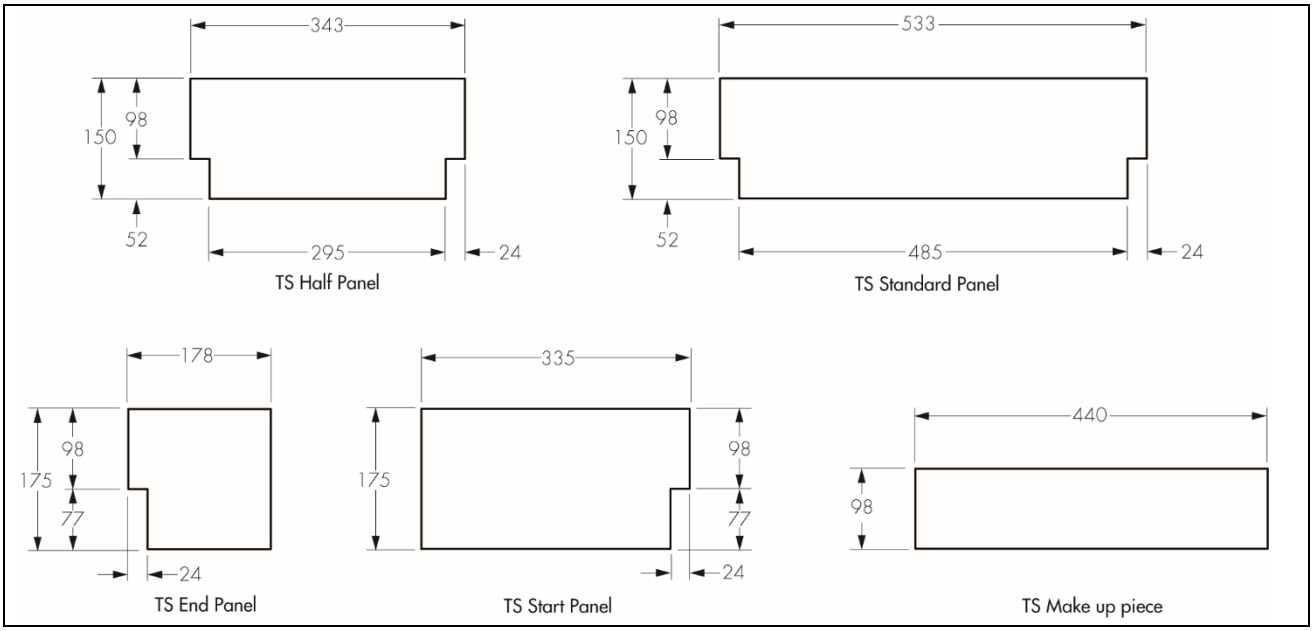
1.3 The TS infill panels (TS standard panel, TS half panel, TS end panel, TS start panel, TS make-up pieces) and top sheets are available in white and grey EPS, with the nominal characteristics given in Table 2 and Figure 2.

Table 2 EPS insulation properties

Property		TS standard panel	TS half panel	TS end panel	TS start panel	TS make up piece	Top sheet
Length (mm)		1220					2400
Top width (mm)		533	343	178	335	440	1200
Bottom width		485	295	154	311	440	1200
Thickness (mm)		150	150	175	175	98	75, 100, 125, 150 and 200
The declared level of compressive stress of EPS at 10% deformation to BS EN 13163 : 2012 (kPa)		CS (10) 70				CS (10) 150	CS (10) 150
Bending strength to BS EN 13163 : 2012 (kPa)		115				200	
Declared level of compressive creep to BS EN 13163 : 2012		—					CC(2/1.5/50)45
Mechanical resistance according to BS EN 15037-4 : 2010 (kN)		1.5					—
Type and class of EPS according to BS EN 15037-4 : 2010		Type R1 and Class R1a					—
Thermal conductivity λ_D value ($W \cdot m^{-1} \cdot K^{-1}$)	Grey	0.030					0.030
	White	0.038					0.034
Moisture diffusion coefficient (μ) in accordance with BS EN 13163 : 2012		20 to 40(1)					30 to 70

(1) It is recommended that the least favourable value is used in calculations of risk of interstitial condensation; see section 8.1.

Figure 2 Dimensions of TS infill panels



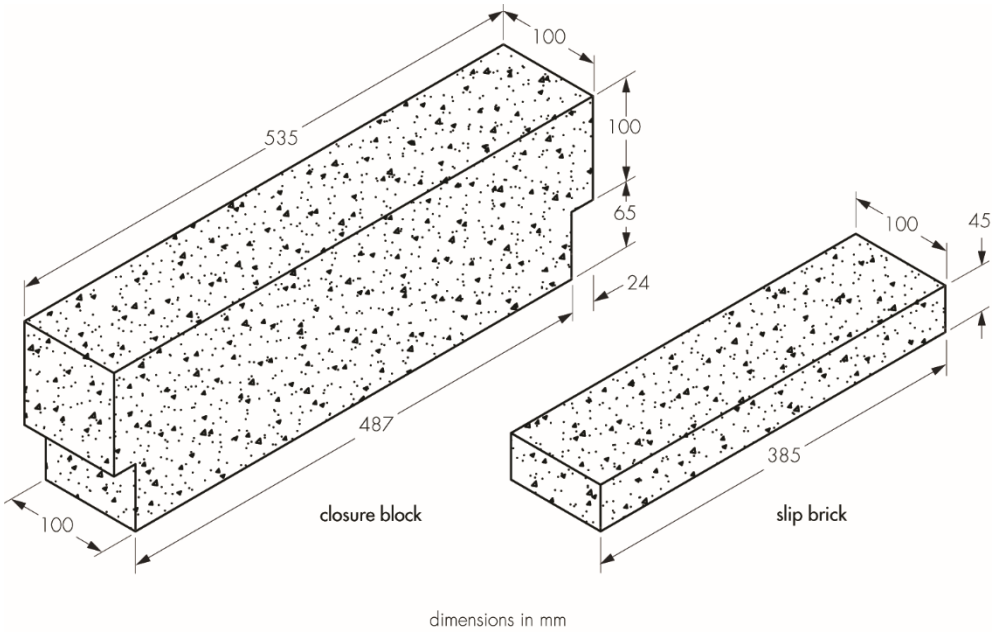
1.4 Ancillary items used in conjunction with the Rackham TS System as specified by the Certificate holder include:

- the concrete perimeter slip bricks and closure blocks (Poly Closure Blocks) – available in the dimensions given in Figure 3 and with a minimum compressive strength of 10 $N \cdot mm^{-2}$. The Poly-Closure Blocks have an inverted T-

shape, profiled to fit between the beam-bearing ends, over the supporting wall and avoid the need to cut blocks/bricks to size. The compressive strength of closure blocks must be equal to, or greater than, that of the blocks used to form the inner leaf of the wall.

Note: The declared compressive strength of masonry unit must be in accordance with Table 6 of Approved Document A.

Figure 3 Typical concrete perimeter blocks and slip-bricks



- structural concrete topping reinforced with steel mesh — specification depends on the proposed floor usage (specification details given in Table 3 of this Certificate). The structural concrete topping reinforced with steel mesh must be designed in accordance with BS EN 1990: 2002 and BS EN 1992-1-1 : 2004 (Eurocode 2) and their respective UK National Annexes, with a maximum aggregate size of 20 mm
- concrete topping(1) reinforced with macro-polymer or steel fibre with maximum aggregate size of 20 mm (specification details given in Table 3 of this Certificate)
- concrete topping(1) reinforced with micro-polymer fibres(2) with maximum aggregate size of 10 mm (specification details given in Table 3 of this Certificate).

(1) The concrete used in the concrete toppings must comply with BS EN 206 : 2013, BS 8500-1 : 2015 and BS 8500-2 : 2015.
(2) NHBC do not accept micro-polymer-fibre structural concrete toppings (see Table 3, footnote 10 of this Certificate).

- 30 mm insulation strips — for application around the perimeter of the structural concrete toppings.

1.5 Ancillary items outside the scope of this Certificate include:

- where required, gas barrier membranes(1) with third-party approval
- vapour control layer (VCL)(1)
- damp-proof membranes (DPM)(1) with third-party approval
- spacer and spreader plate for steel reinforcement.

(1) Must be compatible with EPS.

2 Manufacture

2.1 The pre-stressed concrete beams are cast in moulds and are de-tensioned when the concrete has achieved adequate strength.

2.2 The TS infill panels and top sheets are manufactured from expanded polystyrene beads using conventional moulding techniques.

2.3 The concrete perimeter slip-bricks and closure blocks are manufactured by a conventional static block-making machine. Quality control checks are in accordance with BS EN 771-3 : 2011 and BS EN 772-2 : 1998 and include checks on dimensions, compressive strength and flexural strength.

2.4 As part of the assessment and ongoing surveillance of product quality, the BBA has:

- agreed with the manufacturer the quality control procedures and product testing to be undertaken
- assessed and agreed the quality control operated over batches of incoming materials
- monitored the production process and verified that it is in accordance with the documented process
- evaluated the process for management of nonconformities
- checked that equipment has been properly tested and calibrated
- undertaken to carry out the above measures on a regular basis through a surveillance process, to verify that the specifications and quality control operated by the manufacturer are being maintained.

2.5 The management system of Rackham Housefloors Ltd has been assessed by the BBA and registered as meeting the requirements of BS EN ISO 9001 : 2015 (Certificates 14/Q038, 14/Q039, 14/Q040 and 14/Q041) and BS EN ISO 14001 : 2015 (Certificates 10/E006-1, 10/E006-2, 10/E006-3 and 10/E006-4).

3 Delivery and site handling

3.1 Care must be taken when unloading, stacking and storing the pre-stressed concrete beams to prevent damage. They should be lifted as near as possible to each end and must remain the correct way up at all times. On site, concrete beams must be stored on timber bearers on suitably level ground.

3.2 The pre-stressed concrete beams should be stacked horizontally, one above the other. Timber bearers should be placed close to the beam ends (within 300 mm) and vertically aligned.

3.3 The advice of the Certificate holder should be sought when the storage of unprotected beams on site exceeds three months.

3.4 The polystyrene components are shrink-wrapped in packs. Reasonable care must be taken during transit and storage to avoid damage. On site, they should be stacked on a flat base, clear of the ground and protected against direct sunlight and secured to avoid damage.

3.5 Care must be taken to avoid the polystyrene components coming into contact with solvents and materials containing volatile organic components (such as coal tar, pitch and timber newly treated with preservative). In addition, they must not be exposed to flame or ignition sources; careful consideration should be given to the management of fire risk when in storage.

3.6 The concrete perimeter slip-bricks and closure blocks are delivered to site shrink-wrapped to pallets and should be stacked on a suitable flat base.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on the Rackham TS System.

Design Considerations

4 General

4.1 The Rackham TS System is satisfactory for use as part of a suspended ground floor (over a sub floor void) in a single-family dwelling where the loads given in section 6.12 of this Certificate are not exceeded.

4.2 A suitably experienced/qualified engineer should perform a site-specific assessment/design to ensure that:

- the EPS top sheet, TS infill panels and TS make-up pieces, concrete beam and structural concrete topping are suitable for the intended use, based on the recommendations contained in this Certificate and the relevant parts of BS EN 15037-4 : 2010 and BS EN 15037-1 : 2008

- the floor is not loaded by construction materials until the structural concrete topping has reached its design strength and construction loads do not exceed the design load of the floor
- the floor vibration due to footfall exceeds the natural frequency of 4.0 Hz. The vibration due to rhythmic activity (such as dancing) and external sources (eg building construction or rail traffic) is outside the scope of this Certificate
- lateral restraint is provided at ground floor level in accordance with the requirements of the national Building Regulations, BS EN 8103-1 : 2011 and *NHBC Standards* 2019.

4.3 A void of at least 150 mm deep must be provided for the system, between the underside of the floor and the ground surface.

4.4 In locations where clay heave is anticipated, a greater void depth may be required to accommodate the possible expansion of the ground below the floor. In such cases where the risk of clay heave has been confirmed by geotechnical investigations, a total void of up to 300 mm may be required (refer to *NHBC Standards* 2019) as follows:

- high volume change potential (300 mm total void)
- medium volume change potential (250 mm total void)
- low volume change potential (200 mm total void).

4.5 On sites which may be subject to emissions of gas or volatile organic compounds (VOCs), a suitably experienced and qualified person must assess the compatibility of the insulation with any potential emissions.

4.6 The selected structural concrete topping must be designed and installed strictly in accordance with this Certificate and the Certificate holder's instructions (see section 6.11).The dosage rate for micro-/macro-polymer fibres must be in accordance with Table 3 of this Certificate.

4.7 The tolerance for the batching process and criteria for acceptability of micro-/macro-polymer or steel fibre content must be in accordance with Tables 27 and B.2 of BS EN 206 : 2013.

4.8 For micro-/macro-polymer or steel fibres, the maximum allowed deviation of single test results from limit values, from tolerance on a target value or from the limits of the specified class, should be in accordance with Table 22 of BS EN 206 : 2013.

4.9 Electrical cables running within the TS infill panels (and TS make-up pieces) and top sheets should be enclosed in a suitable conduit, such as rigid PVC. The Certificate holder should be consulted for further advice.

4.10 The system is suitable for use in floors with underfloor heating systems. Care must be taken to ensure that the minimum design thickness of structural concrete topping is maintained, eg above pipes.

5 Practicability of installation

The product is designed to be installed by a competent general builder, or contractor, experienced with this type of system.

6 Strength and stability

6.1 A suitably experienced/qualified engineer must ensure that the concrete beams and structural topping are suitable for the intended application (see section 4.2 of this Certificate).

Top sheets and TS infill panels

6.2 The top sheets in conjunction with the TS make-up pieces provide a permanent formwork for the structural concrete topping. The top sheets also contribute to the short- and long-term structural performance of the floor by transferring the vertical imposed and dead loads to the concrete beams.

6.3 Subject to compliance with the design and installation requirements of this Certificate, the TS infill panels, make-up pieces and top sheets have adequate strength to carry the normal temporary loads expected during the construction phase of the floor system, including the weight of the structural concrete topping.

6.4 The TS infill panels may be cut to accommodate varying beam lengths, must be at least 300 mm long and should be positioned at the floor edges. The widths of the TS start and TS end panels are 335 mm and 178 mm respectively.

6.5 The TS infill panels are designed to have a normal bearing of 18 mm, with a 3 mm allowance for misalignment and manufacturing tolerances in the straightness of the beam, with a minimum bearing width of 15 mm.

6.6 The TS make-up piece (see section 14) is not for use at widths greater than 440 mm**.** The minimum cut length is 300 mm.

6.7 The top sheets have adequate resistance to short- and long-term compressive creep. The strain against stress performance of the top sheets under the applied loads at Serviceability Limit State (SLS) condition remains well below the permitted elastic performance limit of 1 to 1.5%. The long-term thickness reduction of the EPS top sheet remains within the acceptable limit of 2% after 50 years, when subjected to a permanent compressive stress of 0.3 σ10 (σ10 is the compressive stress of the EPS at 10% deformation).

6.8 Spacers for supporting steel mesh reinforcement should be located on spreader plates (dimension not less than 50 by 50 mm and minimum four spacers per m^2) over the top sheets. This will reduce the risk of accidental penetration of the EPS during the construction phase and any resulting misalignment of the reinforcement within the structural concrete topping depth.

Structural concrete toppings

6.9 The concrete forming the topping must be in accordance with BS 8500-1 : 2015, BS 8500-2 : 2015 and BS EN 206 : 2013. Concrete should be manufactured in plants covered by the Quality Scheme for Ready Mixed Concrete (QSRMC), BSI Kitemark or equivalent scheme quality and laid by personnel with appropriate skill and experience.

6.10 The structural concrete topping above the start and end panels must be designed as a cantilever slab (see also section 6.4) and must not exceed 335 mm.

6.11 Full scale testing and calculations indicate that the concrete topping specifications listed in Table 3, in conjunction with the concrete beams defined in Table 1 and the TS infill panels, TS make-up pieces and top sheets specified in Table 2, are suitable for the characteristic loads defined in Table 4 of this Certificate.

Table 3 Specification of structural concrete topping and method of verification[1][2][3][4][5]

No	Reinforcement of concrete topping	Method of verification of concrete toppings
1	One layer of A142 mesh to BS 4483: 2005 with a characteristic yield strength (fyk) of 500 $N \cdot mm^{-2}$. Reinforcement should be placed at mid height of the concrete slab	Calculation to BS EN 1992-1-1 : 2004 and its UK National Annex and full-scale test
2	Durus S400[6][7] (macro-polymer fibre), dosage rate 4.0 $kg \cdot m^{-3}$, 45 mm long, 0.9 mm diameter, tensile strength 465 $N \cdot mm^{-2}$ and modulus of elasticity 3350 $N \cdot mm^{-2}$	Full-scale test
3	Novomesh B&BA[6][8][9] (steel fibre), dosage rate 17.5 $kg \cdot m^{-3}$, steel flat end, steel fibres, fibre length 50 mm, diameter 1.0 mm, tensile strength 1150 $N \cdot mm^{-2}$	Structural calculation of the ultimate bending moment capacity in accordance with 'equation 6' of *TR34* (fourth edition, March 2016)
4	Novomesh B&BA[6][7][8] (macro-polymer and micro-polyolefin fibre), dosage rate 3.84 $kg \cdot m^{-3}$, shape of macro fibre: continuously deformed, 60 mm long, 0.56 mm diameter, tensile strength 600 $N \cdot mm^{-2}$, modulus of elasticity 7000 $N \cdot mm^{-2}$	
5	Adfil SF86[6][8][9] (steel fibre), dosage rate 13.33 $kg \cdot m^{-3}$, 60 mm long, diameter 0.75 mm, tensile strength 1225 $N \cdot mm^{-2}$, modulus of elasticity 200000 $N \cdot mm^{-2}$	
6	Durus Easy Finish[6][7][8] (macro-polymer fibre), dosage rate 3.00 $kg \cdot m^{-3}$, 40 mm long, 0.7 mm equivalent diameter, tensile strength 470 $N \cdot mm^{-2}$, modulus of elasticity 6000 $N \cdot mm^{-2}$	
7	Fibrin X-T[6][10] (monofilament polypropylene micro fibre), minimum dosage rate 0.91 $kg \cdot m^{-3}$, 12 mm long, 22 µm diameter, tensile strength 280 $N \cdot mm^{-2}$	Full-scale test
8	Fibrin 23[6][10] (polypropylene micro fibre), dosage rate 0.90 to 0.91 $kg \cdot m^{-3}$, 12 mm long, 19.5 µm diameter, tensile strength 312 $N \cdot mm^{-2}$	Alternative acceptable micro fibre

(1) The overall depth of concrete topping above the services is 75 mm.
(2) All of the fibres in this Table can be used within a C28/35 standard concrete (see note 3, below) with maximum 20 mm aggregate (see note 5, below) or within a C28/35 self-compacting concrete (see note 4, below) with maximum 10 mm aggregate (see note 5, below).
(3) For standard concrete, the slump should be Class S3 (100 to 150 mm) or S4 (for spot samples taken from initial discharge, 140 to 230 mm).
(4) For self-compacting concrete, the slump flow class should be SF1 (550 to 650 mm) or SF2 (660 to 750 mm). The sand content should be greater than 45%.
(5) The aggregate for concrete must comply with BS EN 12620: 2002.
(6) The steel and polymer fibres for concrete topping must comply with BS EN 14889-1 : 2006 and BS EN 14889-2 : 2006 respectively.
(7) For fresh concrete, macro-polymer fibres content should be measured in accordance with BS EN 14488-7: 2006
(8) The dosage rates of steel and polymer fibres defined in this Table 3 include 15% additional fibres and are designed to give the minimum required residual flexural tensile strength of concrete toppings with steel and macro-polymer fibres.
(9) For fresh and hardened concrete, steel fibres content should be measured in accordance with BS EN 14721 : 2005.
(10) Micro-polymer fibre structural concrete toppings are not accepted on NHBC sites.

6.12 Permitted loadings for structural concrete topping reinforced with micro-/macro-polymer, steel fibres and steel mesh A142 are given in Table 4 of this Certificate.

Table 4 Imposed and partition loads for structural concrete topping reinforced with micro-/macro-polymer, steel fibres and steel mesh A142

Description	Characteristic value of loads for single-family dwellings
Imposed uniformly distributed load (UDL) ($kN \cdot m^{-2}$)	1.5[1]
Imposed concentrated load (kN)	2.0[1][2]
Line-load partition, parallel and perpendicular to the beam ($kN \cdot m^{-1}$)	1.0[3][4], 3.0[3]
Allowance for moveable partition ($kN \cdot m^{-2}$)	1.0[3]

(1) Imposed concentrated load must not be combined with the imposed UDL or other variable actions.
(2) Imposed concentrated load for residential buildings is assumed to be applied over a square plate of area not less than 100 by 100 mm.
(3) Either the line load or allowance for moveable partitions must be accounted for.
(4) For concrete topping reinforced with micro-polymer fibre, the non-load bearing partition walls heavier than 1.0 $kN \cdot m^{-1}$, must bear directly on the foundation or the concrete beams, which must be designed to resist this loading.

6.13 The maximum length of the cantilever slab from the top face of the concrete beam should not exceed 335 mm.

6.14 The maximum distance of the concentrated load applied on the cantilever from the top face of the beam must not exceed 247 mm ($335^{(1)} – 42^{(2)} - 50^{(3)} + 4^{(4)} = 247$).

(1) Length of TS start panel.
(2) Thickness of plasterboard, skirting board and skim.
(3) Half width of a 100 mm square plate (imposed concentrated load for residential buildings is assumed to be applied over a square plate not less than 100 by 100 mm.
(4) Upper taper of the concrete beam.

Pre-stressed concrete beam

6.15 The TS top sheets, TS start, TS end, TS half and TS full panels and TS make-up ieces are for use with self-bearing pre-stressed concrete beams, normal weight concrete, which provides the final strength of the floor system independently of any other constituent part of the floor system (see Table 5 for example of load span table).

Table 5 Example of maximum effective spans (mm) to BS EN 1992-1-1 : 2004, self-weight of floor, 75 mm structural *concrete topping, imposed load of 1.5 kN·m^{-2} and an additional allowance of 0.5 kN.m^{-2} for timber stud partitions*

Beam type	**Beam centres (mm)**	**Maximum effective span (mm)**	
		Without timber stud partitions	**With timber stud partitions (0.5 kN·m^{-2})**
3-wire Standard	596	4366	4117
5-wire Standard	596	5000	4700
8-wire (Wide Beam)	651	5900	5500

Notes:

- The values of the maximum effective spans do not allow for concentrated imposed load.
- The maximum effective span of the concrete beam should be calculated based on simply supported and self-bearing beams.
- For service, ultimate bending and shear resistance of the concrete beams, refer to Table 1 of this Certificate.
- For calculation of ultimate load applied to the beam, the equation 6.10 from BS EN 1990: 2002 was used.
- For calculation of service load applied to the concrete beam, the equation 6.15b (frequent combination) from BS EN 1990: 2002 was used.
- The lowest effective span obtained from the equation 6.10 and 6.15b has been considered as the maximum effective span of the concrete beam.

6.16 The serviceability deflection limit of the concrete beam should be in accordance with BS EN 1992-1-1 : 2004 and is summarised in Table 6 of this Certificate.

Table 6 Deflection limitation of pre-stressed concrete beams

Description	Limit for deflection
Camber at transfer (upward deflection) of pre-stressed force under the self-weight of the concrete beam	Span/250
Deflection at application of finishes – downward from the level of the bearings	Span/250
Deflection for long-term quasi permanent loading (M_{QP})(1) after losses in pre-stress force and creep measured from below the level of the bearings. Ec,eff(2)(3) should be used, to account for the effect of creep in the concrete	Span/250
Movement after application of finishes – increase in deflection due to pre-stress loss and creep	Span/500

(1) M_{QP} is the moment under the quasi-permanent load combination (refer to equation 6.16a of BS EN 1990: 2002).
(2) Effective modulus of elasticity of concrete obtained from equation E_{cm} /(1+Ψ), where Ψ is the long-term creep coefficient of the concrete beam and assumed to be equal to 2.
(3) For limestone and sandstone aggregates, the value of E_{cm} should be reduced by 10 and 30% respectively.

6.17 A suitably experienced/qualified engineer must ensure that the natural frequency (*f*) of the concrete beam due to footfall(1) is greater than 4 Hertz (Hz) as defined below for each floor under the specified loading conditions:

(a) The concrete beam should have a natural frequency greater than 4 Hz when loaded with full dead load plus 0.1 x imposed load (UDL)
(b) The natural frequency (*f*) in Hz of a simply supported concrete beam under UDL loading is determined from equation $f = 18/\Delta^{0.5}$, where Δ is the deflection of the concrete beam in mm for imposed UDL as defined in item (a) above and UDL dead loads.

(1) Use of the system where vibration due to rhythmic activity (such as dancing) and external sources (eg building construction or rail traffic) may be encountered are outside the scope of this Certificate.

6.18 The concrete beam is self-bearing and no account should be made for possible composite action between the beams and the top sheet or the structural concrete topping.

6.19 The minimum bearing length to support the concrete beam is 90 mm, in accordance with BS EN 8103-1 : 2011.

6.20 Where two or more concrete beams are placed side by side, eg beneath load bearing walls, the spaces between the beam webs should be in-filled with concrete with a minimum strength class of C25/30, to give unity of action.

7 Thermal performance

7.1 The overall floor U value will depend significantly on the deck U value, the ratio of the exposed (and semi-exposed) floor perimeter length to floor area (p/a), the amount of underfloor ventilation and the ground thermal conductivity. Each floor U value, therefore, should be calculated to BS EN ISO 13370 : 2017 and BRE Report 443 : 2006.

7.2 A floor deck U value (from inside to the underfloor void) will depend significantly on the types and number of precast concrete beams, infill panels and the top sheet. The thermal resistance of each T-beam and EPS configuration should be numerically modelled to BS EN ISO 10211 : 2017 and BS EN 15037-4 : 2010. The floor deck U value may then be taken as an area-weighted average and the overall floor U value calculated as described in section 7.1.

7.3 Example floor U values given in Table 7 indicate that the system can enable a floor to meet, or improve upon, the design floor U values of between 0.13 and 0.25 $W \cdot m^{-2} \cdot K^{-1}$ specified in documents supporting the national Building Regulations.

Table 7 Example floor U value(1) for single beam configurations(2) (W·m^{-2}·K^{-1})

Beam option	p/a ratio	EPS 150 top sheet	
	m/m^2	75 mm white(3)	150 mm grey(4)
Standard beams (3- and 5-wire) (see Figure 1 of this Certificate)	0.4	0.16	0.11
	0.6	0.17	0.11
	0.7	0.17	0.11
	0.9	0.18	0.11
Wide beam (8-wire) (see Figure 1 of this Certificate)	p/a ratio	EPS 150 top sheet	
	m/m^2	75 mm white(3)	150 mm grey(4)
	0.4	0.17	0.11
	0.6	0.18	0.11
	0.7	0.18	0.11
	0.9	0.19	0.12

(1) These calculations are in accordance with sections 7.1 and 7.2 and assume:
- the T-beam λ is 2.0 W·m^{-1}·K^{-1} and 75 mm concrete topping λ is 1.15 W·m^{-1}·K^{-1}
- a 300 mm thick perimeter wall with a U value of 0.35 W·m^{-2}·K^{-1}
- underfloor ventilation area is 0.0015 m^2·m^{-1}
- ground conductivity is 1.5 W·m^{-1}·K^{-1}
- all other parameters are default values from BRE Report BR 443 : 2006.

(2) Configuration used – 100% single beams at full centres.
(3) Infill panel is EPS 70 white.
(4) Infill panel is EPS 70 grey.

Junction ψ-values

7.4 Care must be taken in the overall design and construction of junctions between the floor and external, internal and party walls, to limit excessive heat loss and air infiltration.

7.5 The junction ψ-values given in Table 8 may be used in Standard Assessment Procedure (SAP) calculations. Alternatively, values can be modelled in accordance with the requirements and guidance in BRE Report BR 497 : 2007, BRE Information Paper IP 1/06 and the provisions in the documents supporting the national Building Regulations relating to competency to perform calculations, determine robustness of design/construction and limiting heat loss by air infiltration.

Table 8 Junction Ψ values

Junction	Ψ (Wm^{-1}·K^{-1})
External wall	0.32(1)
Party wall	0.16(1)

(1) Conservative defaults from SAP 2012.

8 Condensation risk

Interstitial condensation

8.1 There is a risk of interstitial condensation forming on the concrete beam which may be persistent. The risk for each case should be assessed, both through the beam and through the insulation, in accordance with BS EN ISO 13788 : 2012 and BS 5250 : 2011, Annex D.3, accounting for the slab construction, dwelling humidity class, dwelling type, dwelling location and use of any VCL and/or gas membranes.

8.2 To help minimise the risk of condensation, the void space beneath the lowest point of the floor construction should be at least 150 mm high, with provision for adequate through-ventilation, in the form of ventilation openings provided in two opposing external walls. The ventilation openings should be sized at not less than 1500 mm^2·m^{-1} run of external wall or 500 mm^2·m^{-2} of floor area, whichever is greater. Where pipes are used to carry ventilating air, these should be at least 100 mm diameter.

8.3 To minimise the risk of interstitial condensation at junctions with external walls, specifiers should ensure that wall insulation extends to at least 150 mm below the bottom of the infill panel.

Surface condensation

8.4 Floors will adequately limit the risk of surface condensation when the thermal transmittance (U value) does not exceed 0.7 $W \cdot m^{-2} \cdot K^{-1}$ at any point and the junctions with walls are in accordance with the relevant requirements of *Limiting thermal bridging and air leakage : Robust construction details for dwellings and similar buildings* TSO 2002 or BRE Information Paper IP 1/06.

8.5 Floors will adequately limit the risk of surface condensation when the thermal transmittance (U value) does not exceed 1.2 $W \cdot m^{-2} \cdot K^{-1}$ at any point and the floors are designed and constructed to BS 5250 : 2011. Additional guidance can be found in BRE Report BR 262 : 2002.

8.6 To minimise the risk of surface condensation at service penetrations, care should be taken to minimise gaps in the insulation layer.

9 Maintenance

The system components are installed within the floor structure and, therefore, do not require maintenance.

10 Durability

10.1 Provided the EPS products are protected in service from organic solvents and substances liable to cause deterioration, they will be effective as insulation for the design life of the building in which they are installed, taken as 60 years.

10.2 The exposure condition beneath a suspended ground floor over a ventilated void and soil is class XC3, in accordance with BS EN 1992-1-1 : 2004. The concrete beam must comply with the requirements of BS EN 13369 : 2018 to have adequate durability for this exposure condition, for a design life of not less than 60 years.

10.3 The durability of the micro-/macro-polymer or steel fibre concrete toppings will be at least equivalent to that of plain concrete of the same grade.

10.4 The structural concrete topping reinforced with steel mesh will have adequate durability for exposure class XC1, for a design life of not less than 60 years.

11 Reuse and recyclability

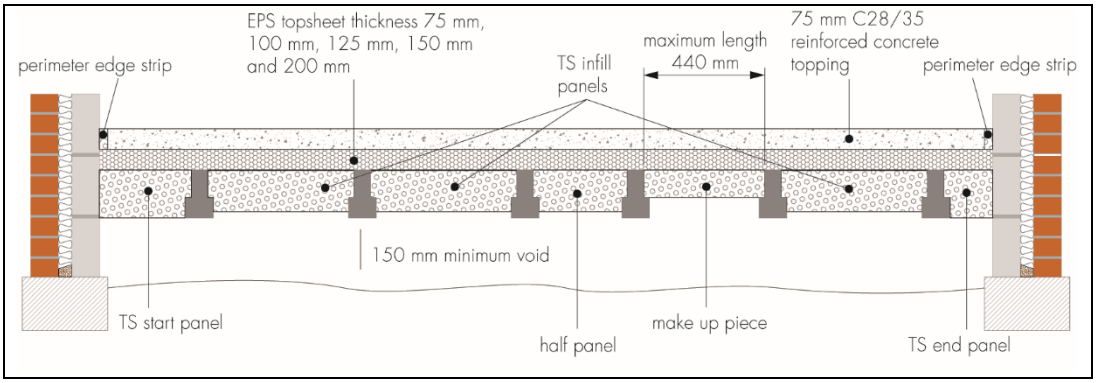
EPS material can be readily recycled if free from debris and contamination. The concrete and reinforcement steel can also be recycled.

Installation

12 General

12.1 Details of typical precast concrete beams and infill panels and top sheet assemblies using the Rackham TS System are shown in Figure 4.

Figure 4 Example Rackham TS System assembly



12.2 Throughout the installation process, due consideration must be given to the relevant health and safety regulations and Certificate holder's product information sheets.

13 Site preparation

13.1 The ground beneath the floor should be free of topsoil and vegetation matter. Oversite concrete or other surface seal is not required, but material added to bring the solum to an even surface should be hard and dry.

13.2 Damp-proofing and ventilation arrangements must be in accordance with normal good practice, eg by the provision of damp-proof sleeves to ventilators and adequate drainage of the sub-floor.

13.3 A continuous damp-proof course should be laid along the support wall below the floor in accordance with BS 8102 : 2009.

14 Procedure

14.1 Beams should be lifted as near to each end as possible and always handled and stacked the 'right way up'. Timber bearers should be used for stacking and placed within 300 mm of the beam ends.

14.2 Prior to installation of the EPS panels, all inner skin cavity wall and internal load-bearing wall blockwork adjacent (parallel) to start and end panels (indicated on the relevant Rackham layout drawing) must be brought up one extra course to provide a vertical surface against which the panels can be installed. The blockwork should be allowed to cure before installation of the start and end panels.

14.3 Firstly, the start panels are positioned against the inside face of the raised wall. The adjacent beam is then moved into position to support the profiled edge of the panel. The square panel face provides a tight friction fit against the block wall. The remaining beams are then installed using the closure blocks (nominal length 535 mm) or a suitable gauge (dependent on the required beam centres) between the beam bearing ends to ensure the correct centres (as shown on the Rackham layout drawing).

14.4 Where beams have to be positioned at irregular (maximum 440 mm) centres due to obstacles (eg at service entrance points) or to facilitate the installation of the end panels, the 98 mm thick make-up piece must be cut to size and fitted tightly between the beams, and bear on the beam shoulders. Where necessary, the panels are cut to length with a handsaw (the minimum usable panel length is 300 mm).

14.5 The remaining area of the floor should then be infilled with TS full, half and end panels as needed.

14.6 If required, a gas/radon barrier should be installed, according to the manufacturer's instructions (see also section 14.11 of this Certificate).

14.7 The top sheet insulation is then laid on top of the infilled beams and over any membrane. Where necessary, the top sheet insulation should be cut to size using a suitable handsaw.

14.8 Perimeter edge strips are installed where necessary, to prevent cold bridging.

14.9 If a steel mesh is specified, spacers should be positioned over spreader plates (minimum four per m² and minimum size 50 by 50 mm). They should be installed to position the steel mesh at the correct level.

14.10 The 75 mm structural concrete topping of strength class C28/C35 containing micro-/macro-polymer or steel fibre or reinforcing steel mesh can then be carefully applied. Concrete must not be dropped from a height exceeding 500 mm and any heaping must not exceed a height of 300 mm.

14.11 Where a VCL, gas membrane or DPM is not placed above the top sheet any gaps between the top sheet boards or around service openings that are visible, prior to installing the concrete must be filled with expanding foam or a strip of insulation. Alternatively, a minimum 75 mm wide suitable tape can be used.

14.12 Good practice should be followed throughout the installation process, to include:

- cube compressive strength and slump tests for concrete topping
- limitation of slump for standard concrete and slump flow for self-compacting concrete
- concrete topping not to be poured at a temperature below 5°C
- the maximum temperature at which the concrete is placed is 30°C and decreasing
- concrete not to be poured during rainfall
- all the ingredients, including the fibres, to be added at the plant mixer.

To prevent shrinkage cracks:

- joints should be incorporated into the slab and appropriate joints between the opening of two adjacent rooms should be provided. Inclusion of joints must not compromise the structural performance of the concrete topping
- where the internal walls are built through the slab, a joint should be formed across the door threshold where the wall separates the two rooms
- an aspect ratio greater than 2:1 should be avoided
- a compressible insulating material around the perimeter of the plot should be provided
- the use of high shrinkage potential aggregate must be avoided
- the water cement ratio should not be increased beyond the limits specified in BS 8500-1 : 2015, BS 8500-2 : 2015 and BS EN 206 : 2013
- steel mesh or loose bars should be placed across re-entrant corners and any openings in the slab greater than 500 x 500 mm
- consideration should be given to the provision of an appropriate slab detail (eg crack inducer) over external walls at the position of porches.

Technical Investigations

15 Tests

15.1 A series of full-scale tests was carried out to ensure the compatibility of the structural concrete topping with the maximum deflection of the concrete beams under service and ultimate loads. The tests were designed to create the maximum curvature of the beam using the micro-/macro-polymer fibre and steel mesh reinforced concrete toppings.

15.2 Full scale tests were carried out to ensure that the short-term strain of the top sheet under the applied loads remained within the permitted elastic performance (1.5%) of the top sheet.

15.3 Prism tests were carried out in accordance with BS EN 14651 : 2005 for steel and macro-polymer fibres.

15.4 Resistance of the EPS infill panels to construction loads has been tested.

16 Investigations

16.1 Evaluation and calculations were made of existing data to assess:

- the adequacy of concrete topping reinforced with steel mesh in terms of thickness, strength class of concrete and diameter of steel reinforcement in accordance with BS EN 1992-1-1 : 2004 and BS EN 15037-1 : 2008

- the adequacy of ultimate bending moment capacities of concrete topping reinforced with macro-polymer or steel fibres in accordance with TR34 (fourth edition) against ultimate applied loads on the floor
- the adequacy of long-term thickness reduction of the EPS top sheet against acceptable limit of 2% after 50 years, when subjected to a permanent compressive stress of 0.3 σ_{10} (σ_{10} is the compressive stress of the EPS at 10 % deformation) was examined
- the durability, practicability of installation and detailing techniques of the system were assessed.

16.2 Floor deck U values were derived by modelling to BS EN 10211 : 2013 and BS EN 15037-4 : 2010 Annex F, and example floor U values calculated to BS EN ISO 13370 : 2017.

16.3 The risk of condensation was determined in accordance with BS 5250 : 2011.

16.4 Thermal conductivity (λ_D) values were investigated.

16.5 Dimensional accuracy and durability were investigated.

16.6 The manufacturing processes for the top sheets and panels were evaluated including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

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17 Conditions

17.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is issued only to the company, firm, organisation or person named on the front page – no other company, firm, organisation or person may hold or claim that this Certificate has been issued to them
- is valid only within the UK
- has to be read, considered and used as a whole document – it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English Law.

17.2 Publications, documents, specifications, legislation, regulations, standards and the like referenced in this Certificate are those that were current and/or deemed relevant by the BBA at the date of issue or reissue of this Certificate.

17.3 This Certificate will remain valid for an unlimited period provided that the product/system and its manufacture and/or fabrication, including all related and relevant parts and processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

17.4 The BBA has used due skill, care and diligence in preparing this Certificate, but no warranty is provided.

17.5 In issuing this Certificate the BBA is not responsible and is excluded from any liability to any company, firm, organisation or person, for any matters arising directly or indirectly from:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- actual installations of the product/system, including their nature, design, methods, performance, workmanship and maintenance
- any works and constructions in which the product/system is installed, including their nature, design, methods, performance, workmanship and maintenance
- any loss or damage, including personal injury, howsoever caused by the product/system, including its manufacture, supply, installation, use, maintenance and removal
- any claims by the manufacturer relating to CE marking.

17.6 Any information relating to the manufacture, supply, installation, use, maintenance and removal of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used, maintained and removed. It does not purport in any way to restate the requirements of the Health and Safety at Work etc. Act 1974, or of any other statutory, common law or other duty which may exist at the date of issue or reissue of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care.