South Kesteven District Council

Deeping Leisure Centre

Pool Hall, Sports Hall and Squash Court

Inspection of roof coverings and assessment.

Report No: **5452 / 01**

Issue: **01**

Survey Date: **13 May 2021**

By: **P Hage**

CEng MICE MIStructE

On behalf of

Siddle Grimley Hage Limited
Consulting Engineers

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1. Introduction

1.1. Siddle Grimley Hage (SGH) was contacted by Mr Kevin Munford of South Kesteven District Council (SKDC) as they had experienced roof leaks at the Deeping Leisure Centre (DLC) and there were concerns that these may have caused structural damage to the building making it unsafe to use.

1.2. Siddle Grimley Hage prepared an initial proposal for investigation works. This included the opening up of roof sections in order to examine the roof construction and to determine if the water ingress had led to any damage to the building structure.

1.3. SGH was instructed by SKDC to undertake the initial site visit and investigation.

1.4. The initial inspection was carried out by SGH on 13 May 2021 with assistance provided by the SKDC appointed contractor. Kevin Munford was also in attendance.

1.5. This report has been prepared exclusively for SKDC. It should not be relied upon by any other person / company, nor should it be used for any other purpose.

2. Background

2.1. We were advised by SKDC and the Leisure Centre Duty Manager that there has been some water ingress through the Swimming Pool and Sports Hall roofs on a number of occasions for a significant number of years and works had been undertaken by SKDC to resolve these issues. Unfortunately, they have often reoccurred or occurred in new locations.

2.2. During a recent heavy rainfall event on the weekend of the 8th and 9th May 2021 significant water ingress was observed and recorded by the Leisure Centre staff to both the swimming pool and sports hall roofs. During our inspection a small amount of water ingress (continuous drips) were recorded in the areas identified by the Leisure Centre staff.

2.3. It is understood that the Leisure Centre was constructed in the mid 1960's. We were advised by SKDC that since then the roofs of both the swimming pool and sports hall have been recovered on two occasions.

2.4. There are no records of the original structure details or of the recovering and remedial works. We were advised by SKDC that the roof finishes had been added to on each occasion.

2.5. The last roof covering (Sika-Trocal single ply) is believed to have been added pre 2000. Recently patching of the joints and alterations to the gutter outlets have been carried out by SKDC in an effort to prevent water ingress.

3. Swimming Pool Roof

3.1. *Locations of water ingress internally*

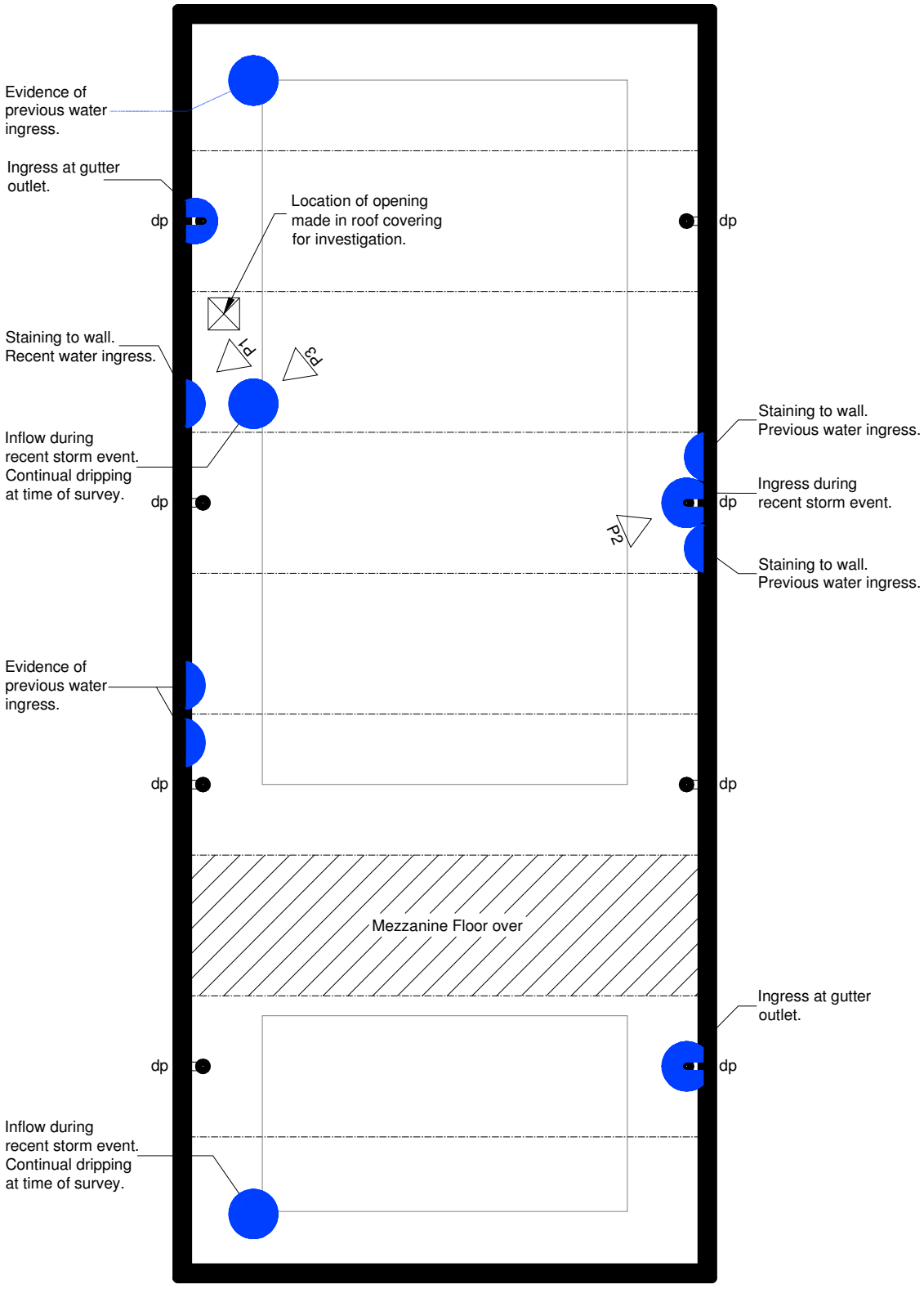
3.1.1. The locations of water ingress through the swimming pool building roof are shown on Figure 1. Record photograph locations are also referenced.

3.1.2. Water ingress during the recent heavy rainfall event was identified to us by the Leisure centre Duty Manager. Evidence of staining within the locations identified would confirm this.

3.1.3. In other areas we noted staining to the ceiling and perimeter walls suggesting previous water ingress. SKDC advised that repairs had been made to the roof covering after previous leaks.

3.1.4. The visual evidence would indicate that the majority of the water ingress in to the pool building occurs adjacent to the side walls (Plate 1) and around the gutter outlets (Plate 2).

3.1.5. In two locations water ingress (continuous dripping) continued at the time of our survey despite it not having rained for at least 4 days (Plate 3).



Swimming Pool Roof
Locations of water Ingress

Figure 1

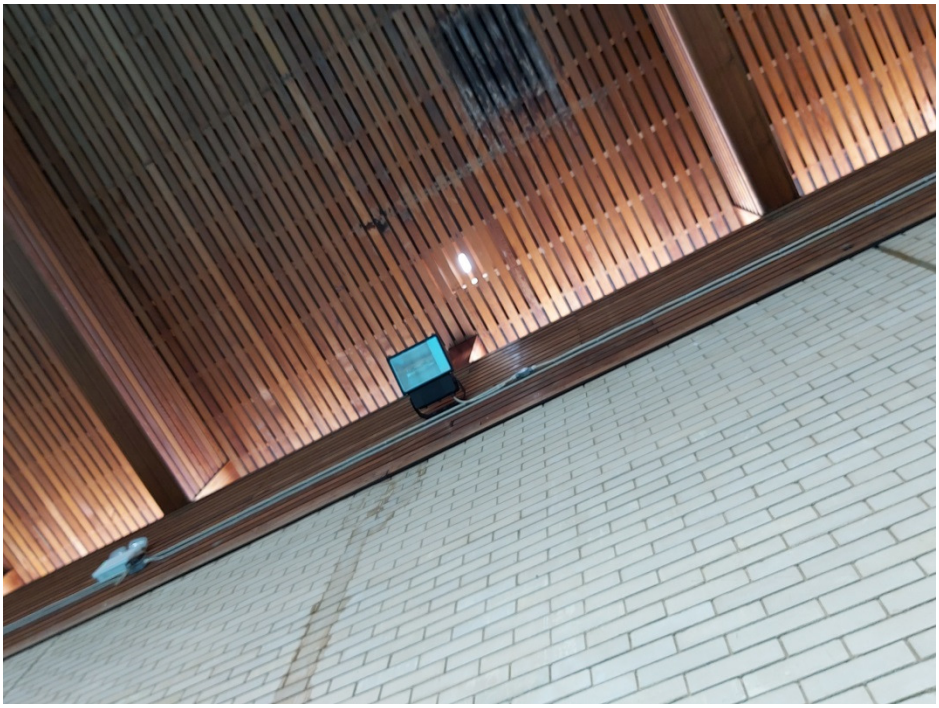


Plate 1
Evidence of water staining to perimeter wall between downpies

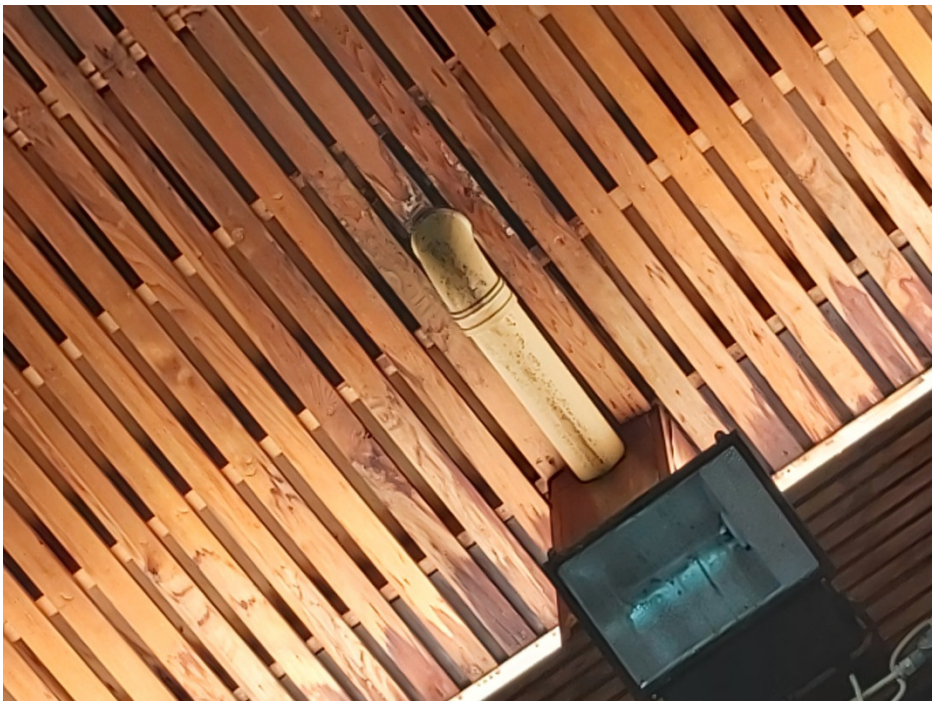


Plate 2
Evidence of water staining to ceiling at gutter outlet penetration

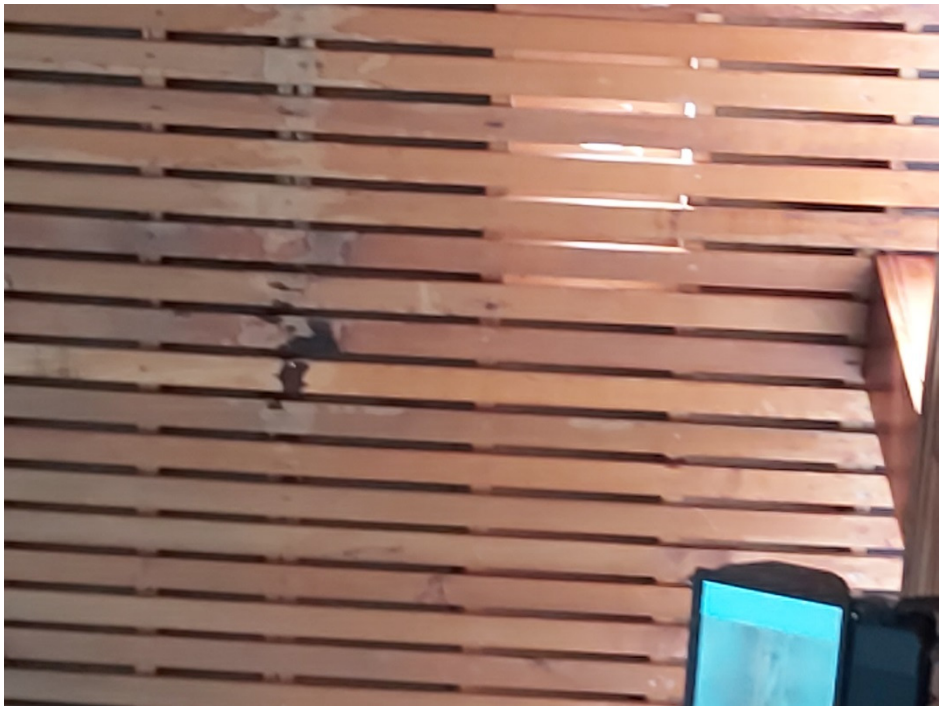


Plate 3

Water ingress at the time of survey

3.2. *Visual Inspection of roof covering*

3.2.1. The current roof covering is a single ply membrane understood to be Trocal by Sika.

3.2.2. The covering was seen to slope upwards along the perimeter of the roof where it meets the small upstand. This has resulted in their being a void between the membrane and the roof insulation. The unsupported membrane is prone to stretch and failure. There is evidence of significant repair to the membrane in these locations (Plate 4).

Plate 4

Single ply membrane lifted at perimeter of roof – Evidence of repair.

3.2.3. The roof covering is secured in position by screws glued to the underside of the membrane. In many locations the screw heads could be seen to have lifted with the membrane stretched over the top (Plate 5). In numerous locations there is evidence of a bituminous repair over the screw head where it has punctured the membrane.

3.2.4. From the investigation it appears that the screws have become partially withdrawn from the roof deck (most likely due to wind suction on the roof). Many of the screws will not push back down into the deck and so they create local high points where the membrane is prone to fail (Plate 6).

Plate 5

Streching of single ply over withdrawn screw.

Plate 6

Exposed screw partially withdrawn.

3.2.5. Previous repairs have been made to the gutter outlets using a rubber membrane material. The inspection found that the joints between the membrane and the gutter outlet had failed to at least three outlets (Plates 7, 8 and 9). This is allowing roof water to track back between the roof deck and the membrane or directly to the outside of the downpipe.

3.2.6. One gully outlet seen appeared to be undersized (Plate 10).

Plate 7

Failed joint between roof covering and outlet.

Plate 8

Failed joint between roof covering and outlet.

Plate 9

Failed joint between roof covering and outlet.

Plate 10

Undersized gutter outlet

3.3. *Intrusive inspection of roof build-up.*

3.3.1. With the assistance of the SKDC appointed contractor a section of the roof covering (location shown on figure 1) was removed.

3.3.2. A cross section of the current roof construction is given in Figure 2 and photograph Plate 11.

3.3.3. The original roof comprised of a bituminous top coat laid over a ply board, supported by timber joists spanning between the primary roof beams. The pool ceiling is under drawn with slatted timbers. The original roof did not appear to have been insulated.

3.3.4. The first roof overlay comprises of polystyrene insulation covered with 3 layer roofing felt and chippings.

3.3.5. The second roof overlay comprises a foil backed insulation board with single ply roof membrane over. The membrane being fixed with screws into the deck.

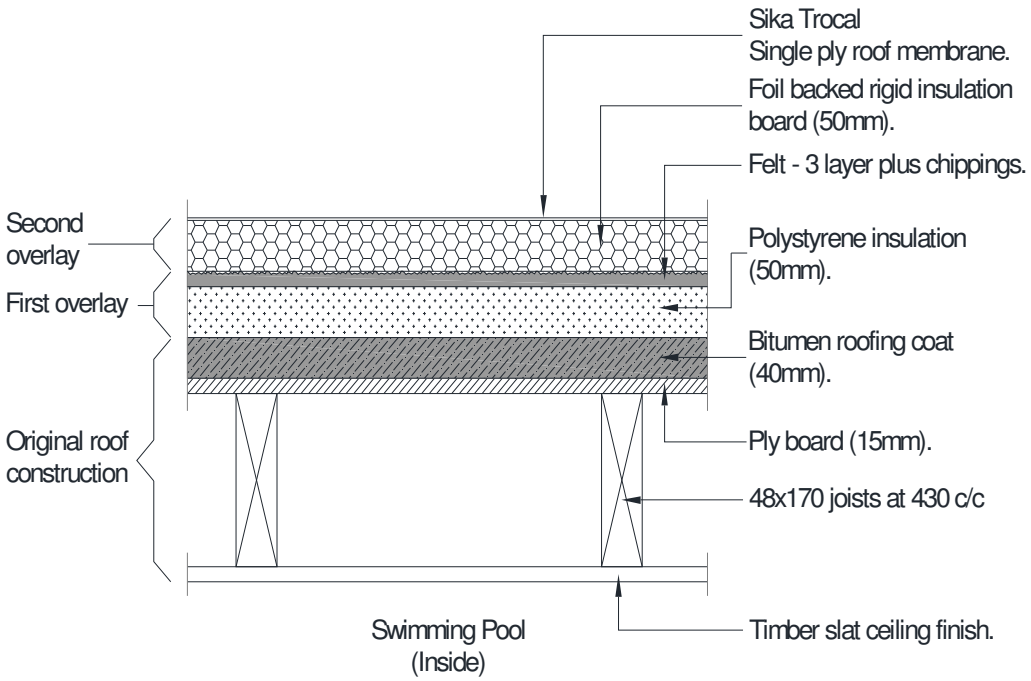


Figure 2

Plate 11

Roof build-up exposed

3.3.6. In the location exposed, a significant amount of standing water was seen between the polystyrene insulation and the original bitumen roof finish. (Plate 11).

3.3.7. This finding would confirm that roof water is breaching both of the overlays.

3.3.8. Water ingress has extended through the lower bituminous layer onto the supporting ply board. The moisture has caused delamination to the top ply of the board, but had not extended beyond this at the inspection point. (Plate 12).

Plate 12

Evidence of damage to top laminate of ply board roof deck.

3.3.9. Significant corrosion was visible to the removed screw fixings (Plate 13).

Plate 13

Corrosion to screw fixings including thread failure

3.4. *Structural member checks*

3.4.1. Given that the roof has been over laid on two occasions since it was originally constructed an assessment has been made to check for member capacity and serviceability of the timber joist spanning between the primary beams.

3.4.2. The structural checks were undertaken in accordance with BS5268-2 with imposed loadings taken from BS 6399-3 and gravity loads based on the site investigation.

3.4.3. Structural calculations are included with Appendix A. A summary of our findings is:

- The timber joists when checked for the original roof load meet the requirements for stress. Deflection was reported to be higher than the code recommends, but is deemed acceptable.
- The current roof construction (with the additional roof weight) was found to cause 13% overstress in the joist. Deflection under dead and imposed load increased to 33mm (Span / 150).

3.4.4. An assessment of the primary roof members could not be undertaken as the investigation did not enable us to expose these members to ascertain their section properties. There was however no visual evidence which would suggest that these members are being overstressed by the current roof loading arrangements which has been in place for a significant time.

3.4.5. We would not advise loading the roof further and would recommend the roof beams are checked if the roof load is not reduced.

3.5. *Discussion from findings*

3.5.1. The water ingress would appear to occur mostly at the roof perimeter. The current membrane has lifted and there have been significant attempts to repair this area of the roof including the creation of channels to direct the roof water to the gutter outlets.

3.5.2. Inspection found that the seal of the roof membrane to the gutter outlet had failed which is allowing the roof water to track into the roof below or pass around the outside of the downpipes directly into the building.

3.5.3. The significant amount of standing water discovered beneath the lower insulation layer would confirm that the first overlay is also failing to prevent water ingress.

3.5.4. The original bitumen roof finish would appear to be preventing significant water ingress hence the extent of standing water seen above it. However there are clearly locations which are allowing the trapped water to pass into the pool area. A likely breach point will be where screws securing the single ply membrane to the board have withdrawn creating a hole through all of the roof layers.

3.5.5. The trapped water may be moved by the normal deformation of the roof due to environmental conditions to breach points where it enters the building. This could occur days after the water entered the roof (as noted during our site inspection) and may not be near to the waters original entry point.

3.5.6. The ply board at the location inspected was seen to be in fair condition. Damage had occurred to the outer lamination but this is not seen to be significantly affecting its structural performance.

3.5.7. Our calculation checks have shown that the additional loading from the two further roof covering have resulted in a 13% overstress to the timber roof joists. Based on this finding alone we do not recommend loading the roof further.

3.5.8. Checks on the primary beams for the current loading are recommended.

3.6. *Conclusions and recommendations*

3.6.1. The existing single ply membrane roof cover has failed. The joints around the gutter outlets and upstands have failed in many locations. The screws holding the membrane down have been pulled out, stretching the membrane and causing holes.

3.6.2. The single ply membrane is believed to be over 25 years old. A well maintained covering has a design life of 30 years but in this instance it has suffered significant design failures. In our opinion the roof covering is beyond repair which would extend its useful life.

3.6.3. Immediate repairs around the gutters and where joints have failed may be able to offer a short term improvement. However we do not have confidence that all defects could be addressed and such repair may only lead to water ingress in other locations.

3.6.4. We would recommend that the roof overlays are removed due to the existing water ingress and overloading of the timber joists.

3.6.5. Covering over is NOT a viable option based on our findings.

3.6.6. Specialist advice should be sought from a roofing contractor on retaining the existing bitumen as removal of this would also likely need the replacement of the ply board.

3.6.7. The screw fixings used to secure the single ply membrane to the ply wood roof sheet are inadequate to resist the wind suction forces. Any replacement roof covering fixings would need to address this issue.

3.6.8. Whilst the ingress of water is unsatisfactory, the visual and intrusive investigations to date did not reveal any damage to the roof structure which would render the building unsafe.

3.6.9. Whilst the primary beams appears to have performed adequately with the additional roof loading over a number of years, we would still recommend that these members are checked if the current roof is to remain over the winter period when there can be additional snow loads.

4. Sport Hall Roof

4.1. *Locations of water ingress internally*

4.1.1. The locations of water ingress through the sports hall building roof are shown on Figure 3. Record photograph locations are also referenced.

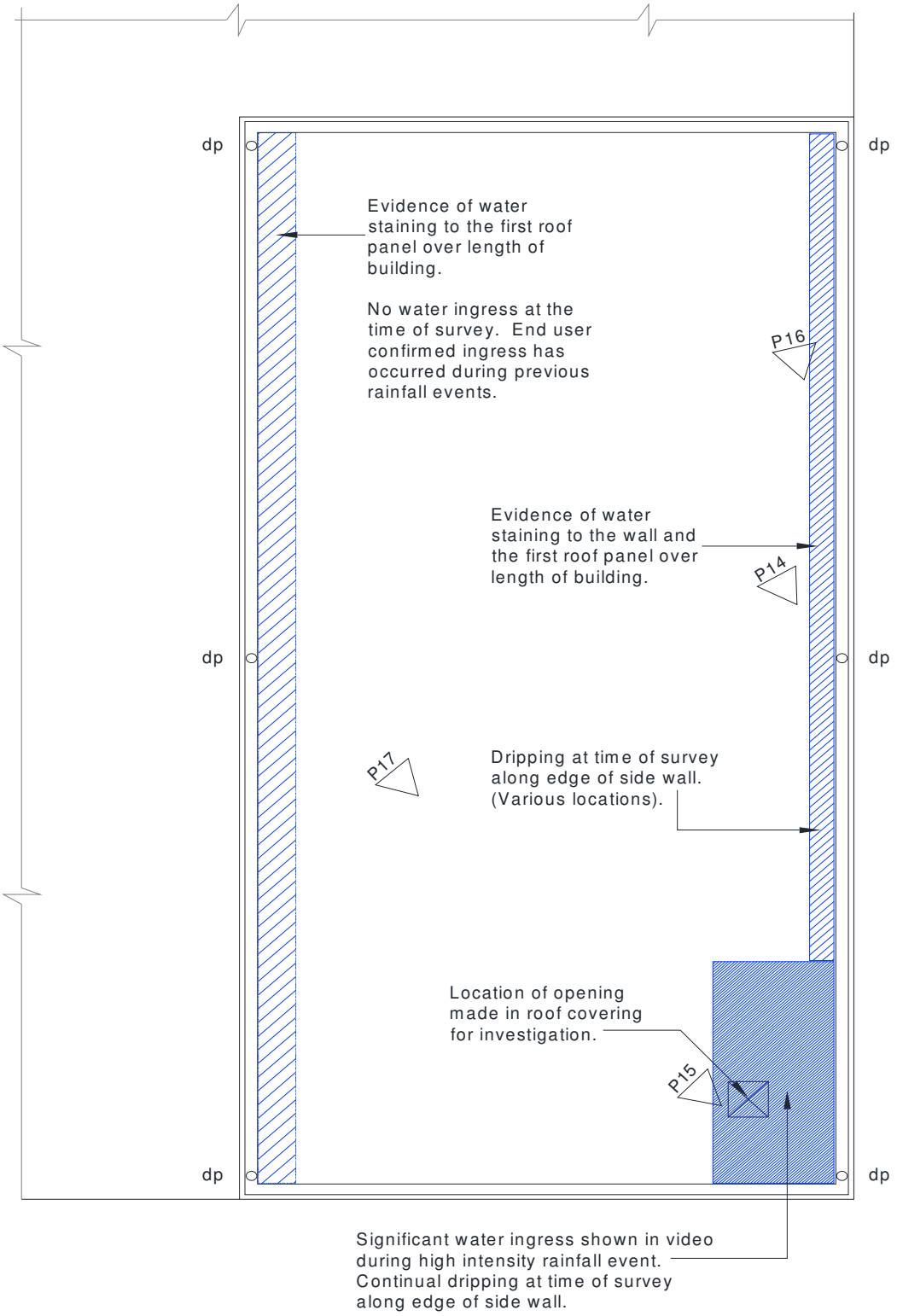
4.1.2. Water ingress during the recent heavy rainfall event was identified to us by the Leisure Centre Duty Manager who also showed a video. The majority of the ingress occurred adjacent to the long wall on the open side of the building (Plate14), with the greatest ingress near to the right hand corner (Plate 15).

4.1.3. In a number of location along the side wall water ingress (dripping) continued at the time of our survey despite it not having rained for at least 4 days requiring the area to be cordoned off and buckets left in place (Plates 16 and 17).

4.1.4. Staining to the underside of the roof was seen to the opposite side of the building adjacent to the long wall. In one location water ingress (dripping) continued at the time of our survey.

4.1.5. SKDC advised that repairs had been made to the roof covering after previous leaks.

4.1.6. Gutter outlets and the down pipes are believed to have been set within the wall cavity as they are not visible to the open side wall.



Sports Hall Roof
Locations of water Ingress

Figure 3

Plate 14

Evidence of water staining to the long wall (open side)

Plate 15

Evidence of water staining to the cornetr of the roof extending into the hall

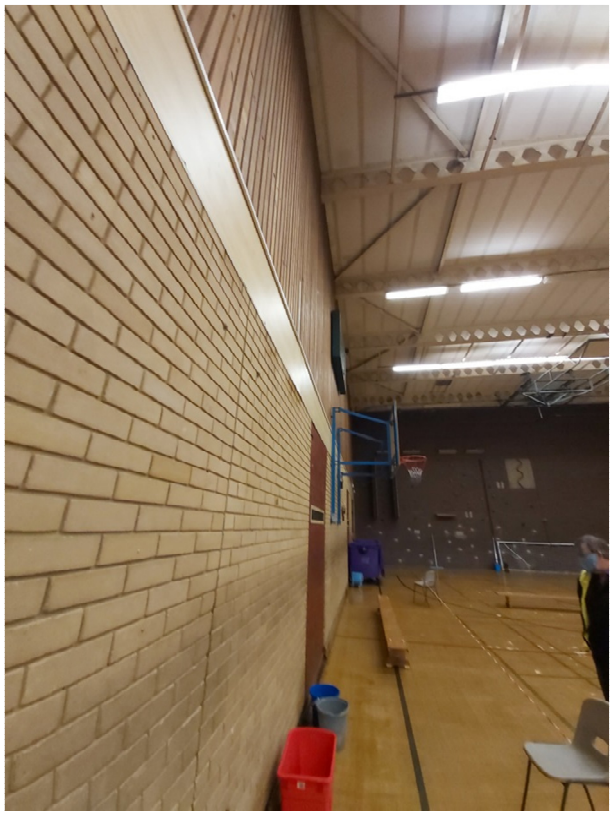


Plate 16

Area cordened off due to continuing water ingress

Plate 17

Area cordened off due to continuing water ingress

4.2. *Visual Inspection of roof covering*

4.2.1. The current roof covering is a single ply membrane understood to be Trocal by Sika.

4.2.2. There were substantial areas of standing water and further areas of staining from previous standing water on the roof where it dips lower than the level of the gully outlet. (Plates 18 and 19).

Plate 18

Standing water and staining due to standing water on single ply membrane.

Plate 19

Dip in roof finish below outlet level.

4.2.3. The roof covering is secured in position by screws glued to the underside of the membrane. In many locations the screw heads could be seen to have lifted with the membrane, causing it to puncture the membrane. A bituminous repair had been applied over the screw heads. (Plate 20).

4.2.4. From the investigation it appears that the screws have become partially withdrawn from the roof deck (most likely due to wind suction on the roof). Many of the screws will not push back down into the deck and so they create local high points where the membrane is prone to fail.

Plate 20

Streching of single ply over withdrawn screw and bitumnet repair.

4.2.5. Sections of the roof covering along the long side, was seen to slope upwards along the perimeter of the roof where it meets the small upstand. This has resulted in their being a void between the membrane and the roof insulation. The unsupported membrane is prone to stretch and failure. There is evidence of significant repair to the membrane in these locations (Plate 21 and 22).

Plate 20

Single ply membrane lifted at perimeter of roof – Evidence of repair.

Plate 21

Single ply membrane lifted at perimeter of roof – Evidence of repair.

4.2.6. Previous repairs have been made to the gutter outlets using a rubber membrane material. The inspection found that the joints between the membrane and the gutter outlet had failed at the two outlets where the most significant water ingress had been recorder internally. (Plates 22 and 23). This is allowing roof water to track back between the roof deck and the membrane or directly to the outside of the downpipe.

4.2.7. The gutter outlets are not fitted with leaf guards.

Plate 22

Rubber membrane has become detached from the gutter outlet.

Plate 23

Rubber membrane has become detached from the gutter outlet and the original roof membrane.

4.3. *Intrusive inspection of roof build-up.*

4.3.1. With the assistance of the SKDC appointed contractor a section of the roof covering (location shown on figure 3) was removed.

4.3.2. A cross section of the current roof construction is given in Figure 4 and photograph Plate 24.

4.3.3. The original roof comprised of a bituminous top coat laid over what appears to be a thin layer of hardboard (disintegrated by opening up works and moisture) onto ‘Stramit’ board.

4.3.4. The first roof overlay comprises of polystyrene insulation board covered with 3 layers roofing felt and chippings.

4.3.5. The second roof overlay comprises rigid insulation board with single ply roof membrane over. The membrane being fixed with screws into the ‘Stramit’ board below.

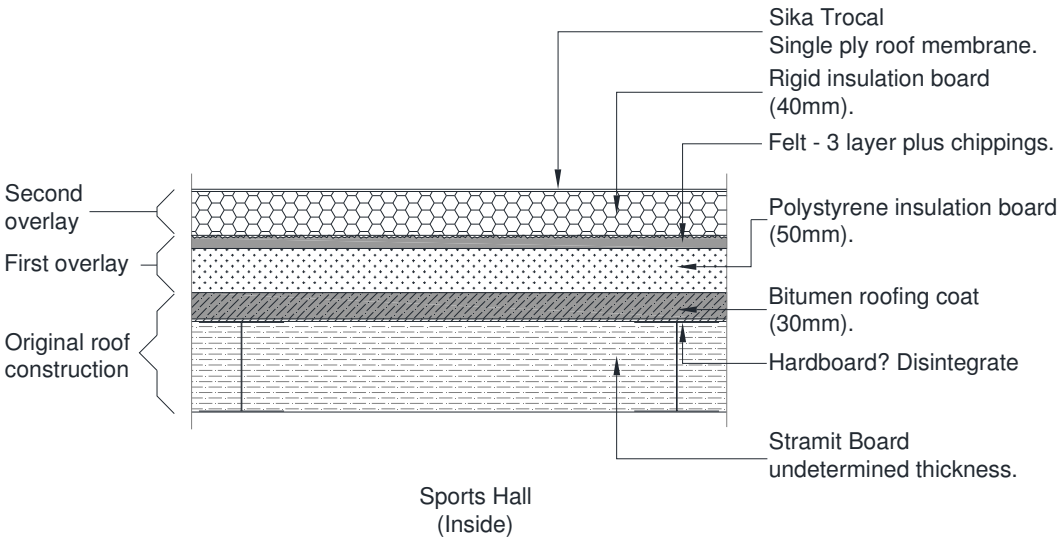


Figure 4

Plate 24

Roof build-up exposed

4.3.6. The ‘Stramit’ board is a matrix of compressed fibres which are impregnated with cement to form boards. It was mainly used in the 1960’s and 70’s. In this instance the boards are set within a pair of steel channels forming a cassette which spans between roof beams. An example of the Stramit board cassette and a comparison of the sport hall cassette where the underside has a finished sheet is shown in Figure 5.

Example
Stramit board cassette
(Viewed from below)

Sport Hall
Stramit board cassette with liner
(Viewed from below)

Figure 5

4.3.7. In the location exposed, trapped standing water was seen between the lower polystyrene insulation and the original bitumen roof finish. (Plate 25 and video).

4.3.8. Cutting through the bitumen layer exposed a brown fibrous material (believed to be hardboard). This was found to be saturated and had disintegrated (Plate 26).

4.3.9. In order to maintain the integrity of the Stramit board the investigation terminated at the top surface.

4.3.10. The investigation confirmed that roof water is breaching all of the roof coverings.

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Plate 25

Trapped water below insulation

Plate 26

Top of Stramit Board

4.4. *Structural member checks*

4.4.1. There are no design guides for assessing the structural performance of the Stramit board. No checks have been undertaken.

4.4.2. The roof cassette construction could not to be determined during our investigation as this would have damaged the element beyond repair (requiring it to be replaced).

4.4.3. The primary roof beams were not accessed during the investigation and therefore were unable to be checked.

4.4.4. Although design checks have not been made, our visual inspection did not identify and signs of excessive deflection of damage which would indicate overstress of the roof cassettes or the primary beams.

4.4.5. We would not advise loading the roof further and would recommend the roof beams are checked if the roof load is not reduced.

4.5. *Discussion from findings*

4.5.1. The water ingress would appear to occur mostly at the roof perimeter and at the gutter outlets. Significant attempts to repair the membrane along the edges of the roof have been made, but there was evidence of failed joints (Plates 20 and 21).

4.5.2. The gutter outlet joints with the roof membrane have been patched, but again these had failed (Plates 22 and 23). The most significant failures being to the gutters above the areas suffering for the greatest water ingress during the recent rainfall event.

4.5.3. Dips were seen in the roof covering creating low spots and stopping water reaching the gutter outlets (Plate 21). Puncturing of the roof membrane caused by the protruding bolts creates a clear path for water to pass through the entire roof construction in these locations.

4.5.4. Each of the roofing layers appear to have breach points which allow water to pass into the building. Other than at screw positions these points of failure may not align and so water passes into each layer and then flows laterally to the next breach point in the layer below. This explains why our investigation discovered trapped water above the bitumen layer, but also found water below it.

4.5.5. The trapped water may be moved by the normal deformation of the roof due to environmental conditions to lower breach points where it enters the building. This could occur days after the water entered the roof (as noted during our site inspection) and may not be near to the waters original entry point.

4.5.6. The junction of the roof covering and the perimeter wall is likely to be prone to failure and would explain why the most significant water ingress occurs at the internal wall face.

4.6. *Conclusions and recommendations*

4.6.1. The existing single ply membrane roof cover has failed. The joints around the gutter outlets and upstands have failed. In many locations the screws holding the membrane down have been pulled out, stretching the membrane and causing holes.

4.6.2. In our opinion the roof covering is beyond repair which would extend its life.

4.6.3. Immediate repairs around the gutters and where joints have failed may be able to offer a short term improvement. However we do not have confidence that all defects could be addressed and such repair may only lead to water ingress in other locations.

4.6.4. In order to investigate the condition of the Stramit board and to make design checks a section of the cassette unit would have to be removed. This was not practical as part of this inspection.

4.6.5. At present the Stramit board cassettes appear to be performing adequately particularly in locations where there has been significant water ingress. However, as design checks could not be made we would not advise increasing the roof loads by covering over

4.6.6. Whilst the primary beams also appear to have performed adequately with the additional roof loading over a number of years, we would still recommend that these members are checked if the current roof is to remain over the winter period when there can be additional snow loads.

4.6.7. Given our finding we recommend that the roof is stripped back to the top of the Stramit board and a new insulated roof covering is fitted. The bitumen layer may be bonded to the Stramit and it may be necessary to retain part of this material. A large scale investigation would be necessary to confirm this and the advice of the specialist roofing contractor sought.

4.6.8. Removing the existing insulation layers is critical to allow all of the trapped water within the roof to be drained and the roof dried out before covering.

4.6.9. The screw fixings used to secure the single ply membrane to the Stramit board roof sheet are inadequate to resist the wind suction forces. Any replacement roof covering fixings would need to address this issue.

4.6.10. Whilst the ingress of water is unsatisfactory, the visual and intrusive investigations to date did not reveal any damage to the roof structure which would render the building unsafe.

5. Squash Court Roofs

5.1. Walk over visual inspection

5.1.1. The roofs to both the original squash courts and those added later (now used as a gym) are covered with a single ply membrane.

5.1.2. Our visual inspection of the roof top surface found many of the same defects seen to the swimming pool and sports hall roofs, including:

i. Withdrawn screws stretching the membrane.

ii. Withdrawn screws puncturing the membrane, with local bitumen repairs.

iii. Lifting of the membrane at roof edges and upstands leaving it unsupported.

iv. Evidence of localised repairs to the membrane at the upstands.

5.1.3. Intrusive investigations were not undertaken due to the known presence of asbestos.

5.1.4. The original quash courts roof was inspected from inside, which showed it to be constructed from Stramit board cassettes as the sports hall.

5.1.5. The ingress of water is understood to occur on the junction line between the original and extended roof at the upstand where the roof membrane has stretched.

5.2. *Conclusions and recommendations*

5.2.1. At present the water ingress is understood to be limited to a single location and is resulting from a failure in the membrane.

5.2.2. Repair to the membrane by a specialist roofing contractor using welded joints may be sufficient to resolve the water ingress in the short term.

5.2.3. The withdrawal of the screws cannot be resolved without replacing the single ply membrane. It is therefore likely that further puncturing and subsequent water ingress will occur to the current membrane.

5.2.4. Consideration should be given to replacing the roof covering within the next five years.

5.2.5. The screw fixings into the ‘Stramit’ board do not appear to be adequate to resist wind uplift. Any proposal for the installation of a replacement roof membrane would need to consider alternative methods of restraint.

APPENDIX A

Swimming pool roof – Structural calculation checks

Siddle Grimley Hage Ltd.

Civil & Structural Consulting Engineers
Tel: (01522) 697111 Email: design@sghconsulting.co.uk

Project			
SKDC - DEEPINGS LEISURE CENTRE.			
Made by: PAM	Date: 5/21	Checked by:	Job number / Sheet number: 5452 / SPR / 1.

SWIMMING POOL ROOF.

SINGLE PLY	0.07	
RIGID INSULATION BOARD (50 mm)	0.05	
LAYER 3	0.12. kN/m²	
3 LAYERS ROOFING FELT + CHIPPINGS	0.35	
INSULATION - POLYSTYRENE (50m)	0.04	
LAYER 2.	0.39 kN/m²	
BITUMEN ROOF FINISHES (40m)	0.45	
PLY BOARD (15mm)	0.10	
JOISTS 60×220 @ 400 c/c.	0.13 *	EXCLUDED FROM JOIST CHECK.
CEILING - TIMBER SLATS.	0.08	
ORIGINAL ROOF.	0.76 kN/m².	0.63 kN/m² *

IMPOSED LOADING.

SERVICES	0.15.	
ROOF IMPOSED	0.60	
TOTAL IMPOSED	0.75. kN/m²	

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Project	Job no.
SKDC - Deepings Leisure Centre	5452
Calcs for	**Start page no./Revision**
Swimming Pool Roof - Original Loading	/ SPR / 2

Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
PAH	02/06/2021				

TIMBER JOIST DESIGN (BS5268-2:2002)

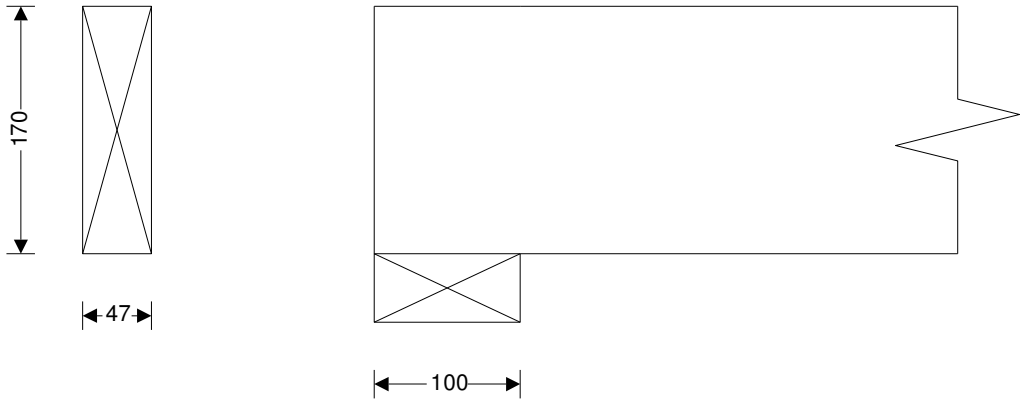
Tedds calculation version 1.1.04

Joist details

Joist breadth	b = **47** mm	Joist depth	h = **170** mm
Joist spacing	s = **400** mm	Service class of timber	**3**
Timber strength class	**C24**		

Span details

Number of spans	N_{span} = **1**	Length of bearing	L_b = **100** mm
Clear length of span	L_{s1} = **4800** mm		



Section properties

Second moment of area	I = **19242583** mm^4	Section modulus	Z = **226383** mm^3

Loading details

Joist self weight	F_{swt} = **0.03** kN/m	Dead load	F_{d_udl} = **0.63** kN/m^2
Imposed UDL(Medium term)	F_{i_udl} = **0.75** kN/m^2		
Imposed point load (Short)	F_{i_pt} = **0.90** kN		

Consider medium term loads

Design bending moment	M = **1.669** kNm	Design shear force	V = **1.391** kN
Design support reaction	R = **1.391** kN	Design deflection	δ = **24.461** mm

Check bending stress

Permissible bending stress	σ_{m_adm} = **8.782** N/mm^2	Applied bending stress	σ_{m_max} = **7.371** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Permissible shear stress	τ_{adm} = **0.879** N/mm^2	Applied shear stress	τ_{max} = **0.261** N/mm^2

PASS - Applied shear stress within permissible limits

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Project				Job no.	
SKDC - Deepings Leisure Centre				5452	
Calcs for				Start page no./Revision	
Swimming Pool Roof - Original Loading				/ SPR / 3	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
PAH	02/06/2021				

Check bearing stress

Permissible bearing stress σ_{c_adm} = **1.980** N/mm^2 Applied bearing stress σ_{c_max} = **0.296** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection δ_{adm} = **14.000** mm Actual deflection δ = **24.461** mm

FAIL - Actual deflection exceeds permissible deflection

Consider short term loads

Design bending moment M = **1.885** kNm Design shear force V = **1.571** kN

Design support reaction R = **1.571** kN Design deflection δ = **24.509** mm

Check bending stress

Permissible bending stress σ_{m_adm} = **10.538** N/mm^2 Applied bending stress σ_{m_max} = **8.325** N/mm^2

PASS - Applied bending stress within permissible limits

Check shear stress

Permissible shear stress τ_{adm} = **1.054** N/mm^2 Applied shear stress τ_{max} = **0.295** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Permissible bearing stress σ_{c_adm} = **2.376** N/mm^2 Applied bearing stress σ_{c_max} = **0.334** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection δ_{adm} = **14.000** mm Actual deflection δ = **24.509** mm

FAIL - Actual deflection exceeds permissible deflection

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Project	Job no.
SKDC - Deepings Leisure Centre	5452
Calcs for	**Start page no./Revision**
Swimming Pool Roof - Current Loading	/ SPR / 4

Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
PAH	02/06/2021				

TIMBER JOIST DESIGN (BS5268-2:2002)

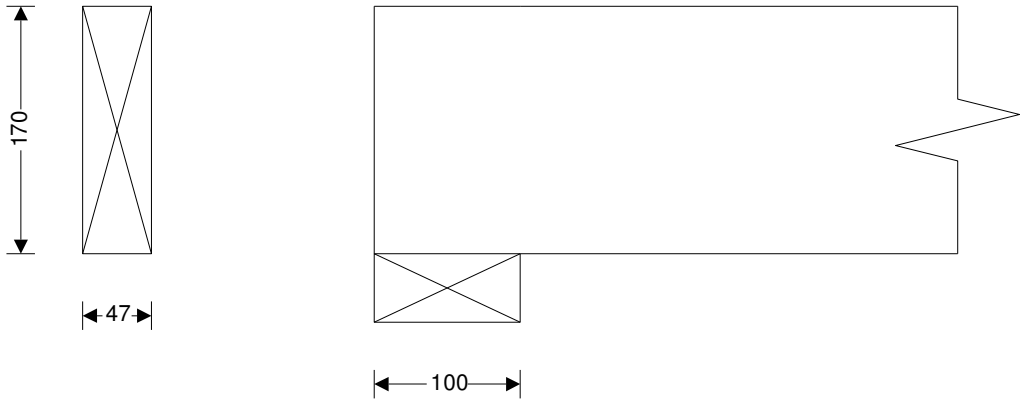
Tedds calculation version 1.1.04

Joist details

Joist breadth	b = **47** mm	Joist depth	h = **170** mm
Joist spacing	s = **400** mm	Service class of timber	**3**
Timber strength class	**C24**		

Span details

Number of spans	N_{span} = **1**	Length of bearing	L_b = **100** mm
Clear length of span	L_{s1} = **4800** mm		



Section properties

Second moment of area	I = **19242583** mm^4	Section modulus	Z = **226383** mm^3

Loading details

Joist self weight	F_{swt} = **0.03** kN/m	Dead load	F_{d_udl} = **1.14** kN/m^2
Imposed UDL(Medium term)	F_{i_udl} = **0.75** kN/m^2		
Imposed point load (Short)	F_{i_pt} = **0.90** kN		

Consider medium term loads

Design bending moment	M = **2.256** kNm	Design shear force	V = **1.880** kN
Design support reaction	R = **1.880** kN	Design deflection	δ = **33.072** mm

Check bending stress

Permissible bending stress	σ_{m_adm} = **8.782** N/mm^2	Applied bending stress	σ_{m_max} = **9.967** N/mm^2

FAIL - Applied bending stress exceeds permissible bending stress

Check shear stress

Permissible shear stress	τ_{adm} = **0.879** N/mm^2	Applied shear stress	τ_{max} = **0.353** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Permissible bearing stress σ_{c_adm} = **1.980** N/mm^2 Applied bearing stress σ_{c_max} = **0.400** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection δ_{adm} = **14.000** mm Actual deflection δ = **33.072** mm

FAIL - Actual deflection exceeds permissible deflection

Consider short term loads

Design bending moment M = **2.472** kNm Design shear force V = **2.060** kN

Design support reaction R = **2.060** kN Design deflection δ = **33.121** mm

Check bending stress

Permissible bending stress σ_{m_adm} = **10.538** N/mm^2 Applied bending stress σ_{m_max} = **10.921** N/mm^2

FAIL - Applied bending stress exceeds permissible bending stress

Check shear stress

Permissible shear stress τ_{adm} = **1.054** N/mm^2 Applied shear stress τ_{max} = **0.387** N/mm^2

PASS - Applied shear stress within permissible limits

Check bearing stress

Permissible bearing stress σ_{c_adm} = **2.376** N/mm^2 Applied bearing stress σ_{c_max} = **0.438** N/mm^2

PASS - Applied bearing stress within permissible limits

Check deflection

Permissible deflection δ_{adm} = **14.000** mm Actual deflection δ = **33.121** mm

FAIL - Actual deflection exceeds permissible deflection