**Kingworks**
STRUCTURAL ENGINEERS
600 Dupont St * Ste B
Bellingham, WA 98225
360-714-8260 www.king-works.com

| | | | |
|---|---|---|---|
| **JOB TITLE** | Forge Fitness | | |
| **JOB NO.** | 24006 | **SHEET NO.** | 1 |
| **CALCULATED BY** | KQH | **DATE** | |
| **CHECKED BY** | | **DATE** | |

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# STRUCTURAL CALCULATIONS

FOR

## Forge Fitness

100 Drayton Avenue
Lynden Wa 98264

Code: International Building Code 2021 Risk Category: II

Loads:

| | | | | |
|---|---|---|---|---|
| Roof: | DL = | 15.4 psf | | |
| | Snow = | 25 psf | Isnow= | 1.00 |
| Wind: | N/A | | | |
| Seismic: | N/A | | Ieq= | 1.00 |

Soils: Basis: N/A
Allowable Bearing Stress: N/A PSF
Lateral Soil Loads (Active / At Rest): N/A

Description:

Kingworks was requested to review the existing roof for the added moisture present in the roof buildup and determine if it reduced the snow load capacity of the existing structure.

KINGWORKS STRUCTURAL ENGINEERS

February 16, 2024

Jeannie Davidson
100 Drayton St
Lynden, WA 98264

Dear Jeannie Davidson,

Kingworks was asked to evaluate the existing roof at Forge Fitness, which has been retaining moisture in the roofing buildup, observed during recent maintenance projects. The objective of our evaluation was to determine whether the weight contributed by moisture in the roofing buildup is overstressing the existing roof structure. I was joined on site on February 5, 2024 with Chad Herrick of Geotest and Jeff Turner. The extents and footprint of the water intrusion is unknown; however, Jeff noted that the majority of issues observed on site have been limited to the pool area. In order to limit repair work, we were requested to limit our evaluation to the roof structure over the pool.

Structure Summary:

The existing structure is a single-story pool structure with several varying construction types. A set of existing architectural drawings, dated 1978, were provided by the contractor. Walls types vary; primary construction consists of 2x8 wood studs. An 8" CMU wall frames the southern portion of the building. The southwest portion of the building is framed with 7" concrete walls. The existing roof over the pool structure consists of 8¾" x 43½" glulam beams at 20ft spacing. The existing glulam beams are supported on steel columns embedded in wood framed walls. 2x12 roof joists at 24" spacing span between glulam beams. 2x3 flat stripping and ½" plywood supported the original mop down roof. At some point after original construction a portion of the roof was supplemented with 2" of rigid insulation, a ½" perlite board, and a second layer of 1½" perlite board, covered with plywood sheathing and a membrane roof. It is at this portion of roof that saturated materials and additional moisture were observed.

Assessment Procedure:

Geotest provided material testing of existing beams and roofing buildup, the results of which are summarized in two separate reports, attached. A moisture meter was used to obtain the moisture content of (4) existing glulam beams at (16) individual locations. The reported moisture content in the glulam beams varied between 9% and 13.5%. (8) 8" square roofing buildup samples were taken to obtain the moisture content of the roofing buildup. The samples were weighed prior to and after oven drying in order to determine the original weight, current weight, and retained moisture. The weight of the retained moisture in the samples varied between 0.1psf and 10.1psf

Jeff Turner provided field measurements of the existing geometry to supplement the original plans. Existing glulam beams and roof joists were analyzed for an established dry weight of 15.4psf and a design snow load of 25psf. Existing glulam beams were analyzed with an additional 5psf moisture weight – an average of the tested samples – and found to be sufficient. Existing joists were analyzed with an additional 10psf moisture weight – the maximum moisture content observed in the tested samples – and found to be approximately 35% overstressed. For reference, the existing joists would be sufficient to support a maximum snow load of approximately 12psf, equivalent to ~8" of snow.

Recommendations:

The amount of moisture located in the existing roof is significant and will need to be addressed for the long-term performance of the building. An envelope consultant should be retained to review the current roof buildup. If/when snow depth on the roof exceeds 4" or there is a rain on snow at any depth the building should be closed to the public as a precaution. Alternatively, installing additional 2x12 joists to supplement the existing joists would strengthen the roof and buy time before a permanent solution could be implemented.

When budget and time allow for the implementation of a permanent solution, we also recommend reviewing the lateral attachment between the existing concrete & CMU walls and the roof structure, if present. This attachment was not detailed in the original drawings and was not able to be observed while on site. Modern codes have found that buildings lacking this attachment tend to perform poorly in a seismic event.

If additional repair work – such as providing additional 2x12 rafters – is required in the short term, we could add that work to our scope.

Sincerely,

Quinn Hanks, PE, Associate

Attachments:

1. Geotest report Dated February 12th, 2024, roofing moisture content testing
2. Geotest report dated February 13th, 2024, beam moisture content testing.
3. Original roof framing plans and details.

KINGWORKS STRUCTURAL ENGINEERS
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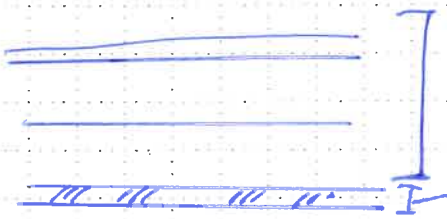
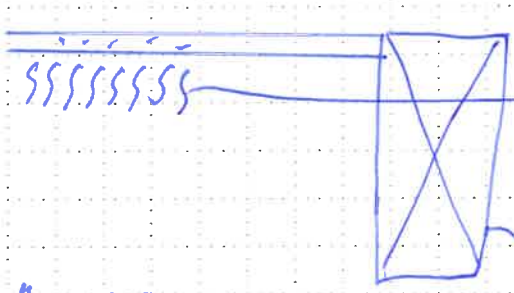
| PROJECT | Forge Fitness | | |
|---|---|---|---|
| DESCRIPTION | Roof wt | | |
| ENGINEER | PROJECT NO. | DATE | PAGE |
| KQH | 24006 | 2/12/2024 | |




2x12 Joist @ 24" oc = 2.2 PSF




Span = 19.5' - 8.5" = 18.8

Σ = 15.4 psf

DL Roof DRY = 15.4 PSF

use 12.7 psf when checking purlins as glb is not added weight on purlins

wet weight max Found = 10.1 psf max saturation Found

GLB capacity = .310 Klf as Dead Load

.310klf/20FT = .0155 ksf x 1000 = 15.5 psf

# kingworks

600 Dupont St * Suite B
Bellingham, WA 98225
Ph 360-714-8260

Project: Forge Fitness
Project #: 024006 Page of
By KQH Date 2/12/2024
Subject Roof beam check

Load Combinations:

| 1 ASD | D | L | L2/S | W(E) |
|---|---|---|---|---|
| ASD1 | 1.00 | 0.75 | 0.75 | 0.00 |
| ASD2 | 1.00 | 1.00 | 0.00 | 0.00 |
| ASD3 | 1.00 | 0.00 | 1.00 | 0.00 |
| ASD4 | 1.00 | 0.75 | 0.75 | 0.75 |
| ASD5 | 1.00 | 0.00 | 0.00 | 1.00 |
| ASD6 | 0.60 | 0.00 | 0.00 | -1.00 |
| Service TL | 1.00 | 1.00 | 1.00 | 1.00 |
| Service LL | 0.00 | 1.00 | 1.00 | 1.00 |

| 1 LRFD | D | L | L2/S | W(E) |
|---|---|---|---|---|
| LRFD 1 | 1.40 | 0.00 | 0.00 | 0.00 |
| LRFD 2 | 1.20 | 1.60 | 0.50 | 1.00 |
| LRFD 3 | 1.20 | 0.50 | 0.50 | 1.00 |
| LRFD 4 | 1.20 | 0.50 | 0.50 | -1.00 |
| LRFD 5 | 0.90 | 0.00 | 0.00 | 1.00 |
| LRFD 6 | 0.90 | 0.00 | 0.00 | -1.00 |
| ServiceTL | 1.00 | 1.00 | 1.00 | 0.00 |
| ServiceLL | 0.00 | 1.00 | 1.00 | 0.00 |

First calculation is 2x12 purlin without any additional moisture weight. Original joists are 6% overstressed in the original condition after the second roof was added

Beam number: **2** Span 18.8 ft Comb 1 ASD Deflection L/() LL 240 TL 240
position: existing roof joist
comments: existing roof rafters; 2x12 @ 24" oc

| | D | L | L2/S | W(E) |
|---|---|---|---|---|
| Wmajor | 0.025 | 0.000 | 0.050 | 0.000 |
| Wminor | 0.000 | 0.000 | 0.000 | 0.000 |
| Axial | 0.000 | 0.000 | 0.000 | 0.000 |

Reactions: max min
RLmajor 0.7 0.1
RRmajor 0.7 0.1
EI Req'd: LLmaj 1.5E+05 TLmaj 2.3E+05

**2** Qty* 1 Name 2x12 DF #2 Edge Bracing(x,ft) 1.0 top 18.8 bottom

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wt | 3.656 | plf | Cr | 1.15 | CfBend | 1.00 | Imaj(zz) | 178 | In4 | Bracing(y,ft) | 18.8 | | |
| d | 11.3 | in | Cd | 1.15 | CfComp | 1.00 | Imin(yy) | 3 | In4 | Wet Use / Incised: | FALSE | FALSE | |
| b | 1.5 | in | CL(pos) | 1.00 | CfTens | 1.00 | | | | Duration Snow | Repetitive | TRUE | (TRUE/FALSE) |
| | | Cm x Ci | Cmisc | CL(neg) | 0.29 | Cfu | 1.20 | Mode | Value | Control:pt:3 | Check | | Max |
| Fb | 900 | 1.00 | 1.00 | Dimension Adj: | | | | Mmajor | 3.3 | 3.1 | 1.06 | FALSE | 1.06 |
| Fv | 180 | 1.00 | 1.00 | b: | 0.0 | | | Vmajor | 0.0 | 2.3 | 0.00 | TRUE | 0.30 |
| E | 1600 | 1.00 | 1.00 | | | | | ΔLlmaj | 457 | 240 | 0.53 | TRUE | |
| | | | | | | | | ΔTlmaj | 303 | 240 | 0.79 | TRUE | |

*Members are not connected for composite action in minor axis bending

2/19/2024 C_SAWN v2.00 11/13/17 FALSE

Beam number: **3** Span 18.8 ft Comb 1 ASD Deflection L/() LL 240 TL 180
position: existing roof joist
comments: existing roof rafters; 2x12 @ 24" oc

| | D | L | L2/S | W(E) |
|---|---|---|---|---|
| Wmajor | 0.045 | 0.000 | 0.050 | 0.000 |
| Wminor | 0.000 | 0.000 | 0.000 | 0.000 |
| Axial | 0.000 | 0.000 | 0.000 | 0.000 |

Reactions: max min
RLmajor 0.9 0.3
RRmajor 0.9 0.3
EI Req'd: LLmaj 1.5E+05 TLmaj 2.1E+05

**3** Qty* 1 Name 2x12 DF #2 Edge Bracing(x,ft) 1.0 top 18.8 bottom

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wt | 3.656 | plf | Cr | 1.15 | CfBend | 1.00 | Imaj(zz) | 178 | In4 | Bracing(y,ft) | 18.8 | | |
| d | 11.3 | in | Cd | 1.15 | CfComp | 1.00 | Imin(yy) | 3 | In4 | Wet Use / Incised: | FALSE | FALSE | |
| b | 1.5 | in | CL(pos) | 1.00 | CfTens | 1.00 | | | | Duration Snow | Repetitive | TRUE | (TRUE/FALSE) |
| | | Cm x Ci | Cmisc | CL(neg) | 0.29 | Cfu | 1.20 | Mode | Value | Control:pt:3 | Check | | Max |
| Fb | 900 | 1.00 | 1.00 | Dimension Adj: | | | | Mmajor | 4.2 | 3.1 | 1.34 | FALSE | 1.34 |
| Fv | 180 | 1.00 | 1.00 | b: | 0.0 | | | Vmajor | 0.0 | 2.3 | 0.00 | TRUE | 0.39 |
| E | 1600 | 1.00 | 1.00 | | | | | ΔLlmaj | 457 | 240 | 0.53 | TRUE | |
| | | | | | | | | ΔTlmaj | 240 | 180 | 0.75 | TRUE | |

*Members are not connected for composite action in minor axis bending

2/19/2024 C_SAWN v2.00 11/13/17 FALSE

Beam number: **7** Span 65.1 ft Comb 1 ASD Deflection L/() LL 240 TL 180
position: Roof Glue Lam beam
comments: Glue lam beam roof framing

| | D | L | L2/S | W(E) |
|---|---|---|---|---|
| Wmajor | 0.408 | 0.000 | 0.500 | 0.000 |
| Wminor | 0.000 | 0.000 | 0.000 | 0.000 |
| Axial | 0.000 | 0.000 | 0.000 | 0.000 |

Reactions: max min
RLmajor 29.6 8.0
RRmajor 29.6 8.0
EI Req'd: LLmaj 6.2E+07 TLmaj 8.5E+07

**7** Qty* 1 Name GLB 8-3/4x43.5 24F-V4 Edge Bracing(x,ft) 2.0 top 2.0 bottom

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wt | 82.47 | plf | Cd | 1.15 | CL(pos) | 1.00 | Imaj(zz) | 60020 | In4 | Bracing (y, ft) | 12.0 | | |
| d | 43.5 | in | Cfu | 1.04 | CL(neg) | 1.00 | Imin(yy) | 2428 | In4 | Wet Use: | FALSE | | |
| b | 8.75 | in | Cv | 0.88 | Southern Pine | | FALSE | | | Duration | Snow | | |
| | | Cm | Cmisc | | | | Mode | Value | | Control:pt:3 | Check | | Max |
| Fb(tz in t) | 2400 | 1.00 | 1.00 | Dimension Adj: | | | Mmajor | 481.0 | | 559.4 | 0.86 | TRUE | 0.86 |
| Fv | 265 | 1.00 | 1.00 | b: | 0.0 | | Vmajor | 0.0 | | 77.3 | 0.00 | TRUE | 0.38 |
| | | | | | | | ΔLlmaj | 418 | | 240 | 0.57 | TRUE | |
| | | | | | | | ΔTlmaj | 230 | | 180 | 0.78 | TRUE | |

*Members are not connected for composite action in minor axis bending

2/16/2024 C_GLB v2.0012/5/17r2/9/19 TRUE

glue lam beam ok

roof purlins with full snow load and additional moisture load with max load of 10.1 psf additional load over the entire length of the joists

GEOTEST
An RMA Company

1.888.251.5276
Bellingham | Arlington | Oak Harbor
www.geotest-inc.com

February 12th, 2024
Job No. 24-0066

**Forge Fitness Roofing Moisture Content Testing**
100 Drayton St
Lynden, WA 98264

**Attn: Jeff Turner**
**Bay Rd. Building & Consulting LLC**
**Re: Roof Moisture Content Testing**

As requested, GeoTest Services, Inc. (GTS) is pleased to submit this test report summarizing the results of moisture content testing of 8 roofing samples.

Locations of roofing samples were selected at the direction of Quinn Hanks from Kingworks Structural Engineers.

## METHODOLOGY AND RESULTS

8" by 8" roofing samples were removed from the existing roof assembly (Figure 1 and 2). In GeoTest's Bellingham, WA laboratory, the samples were weighed, then placed in an oven set at 212F. Samples were weighed daily and were considered dry when the weight loss was less than 10g of weight from the previous day's measurement. Samples took between 7 and 9 days to dry. The dry weights of the samples were recorded once removed from the oven. Samples were then submerged in a bucket of water for 48hrs. After 48hrs of submersion, excess water was removed from the samples by straining the bucket contents through a fine mesh sieve. The weight of the samples after 48hrs of submersion was recorded as the saturated weight.

All samples, except for sample #7, had a thickness of 6" to 6.5". Sample 7 had a thickness of 2.5" yielding far less mass after saturation compared to the other samples.

## RESULTS:

Moisture content (MC) was calculated using dry basis moisture content:

$$\boldsymbol{MC = \frac{(m_{wet} - m_{dry})}{m_{dry}} * 100}$$

Where:
$m_{wet}$: Mass of samples as removed from site
$\mathrm{m_{dry}}$: Mass of samples after 7 days in oven at 212F

***Table 1: Results from moisture content testing.***

| Sample # | Mass as removed from site (g) | Dry mass (g) | Moisture Content (dry basis as removed from site) | Mass after 48hrs of submersion (g) | LB/sqft as removed from site | LB/sqft of dry sample | LB/sqft of sample after submersion |
|---|---|---|---|---|---|---|---|
| 1 | 1198 | 1136 | 5% | 3125 | 6.0 | 5.7 | 15.7 |
| 2 | 1568 | 1105 | 42% | 3289 | 7.9 | 5.5 | 16.5 |
| 3 | 1126 | 1061 | 6% | 2967 | 5.6 | 5.3 | 14.9 |
| 4 | 1706 | 1058 | 61% | 3345 | 8.5 | 5.3 | 16.8 |
| 5 | 2136 | 934 | 129% | 3487 | 10.7 | 4.7 | 17.5 |
| 6 | 1324 | 1245 | 6% | 3185 | 6.6 | 6.2 | 16.0 |
| 7 | 774 | 587 | 32% | 1156 | 3.9 | 2.9 | 5.8 |
| 8 | 3204 | 1193 | 169% | 3624 | 16.1 | 6.0 | 18.2 |

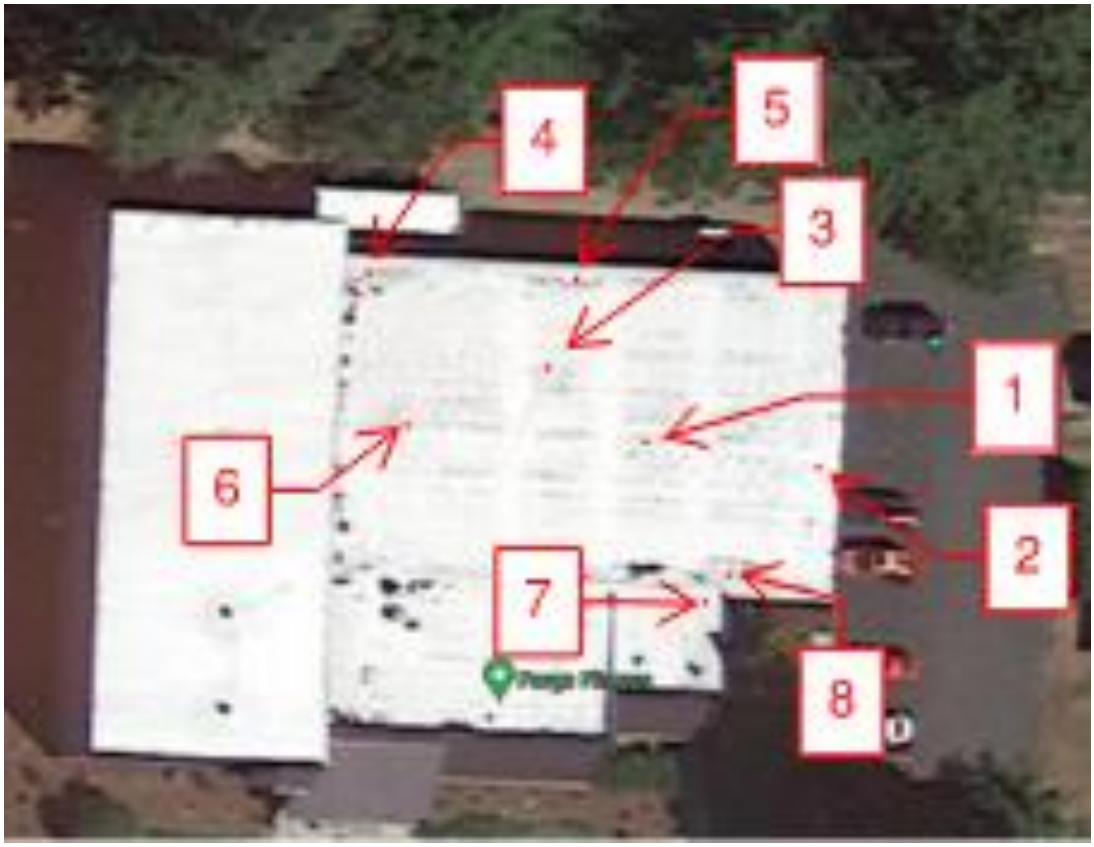



***Figure 1: Location of the 8 samples removed from site.***

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***Figure 2: Removal of sample #4.***

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**DISCUSSION**

Due to the history of multiple re-roofing operations, the assembly had varied layers which contributed to variances in recorded weight. Samples removed from the perimeter of the pool roof (2, 4, 5, and 8) had more saturation than samples removed from the center of the roof. Sample #7 was removed from the mechanical mezzanine roof that had a thinner assembly than the pool roof, thus had less mass.

While pouring the samples after 48 hrs of submersion through a fine mesh sieve, small particles of insulation material could be seen flowing through the mesh, leading to errors in the weight measurement of the saturated samples. The samples could also have absorbed more water if left submerged for longer than 48hrs; therefore, the weight per sq ft of samples after 48 hrs of submersion should not be considered fully saturated.

Respectfully Submitted,
**GeoTest Services, Inc.**

Chad Herrick, PE
Project Engineer, Building Science Division
Attachments: Photo Appendix

GEOTEST
An RMA Company

1.888.251.5276
Bellingham | Arlington | Oak Harbor
www.geotest-inc.com

February 13th, 2024
Job No. 24-0066

**Forge Fitness Glulam Beam Moisture Content Testing**
100 Drayton St
Lynden, WA 98264

**Attn: Jeff Turner**
**Bay Rd. Building & Consulting LLC**
**Re: Glulam Beam Moisture Content Testing**

As requested, GeoTest Services, Inc. (GTS) is pleased to submit this test report summarizing the results of moisture content testing of glulam beams within the pool room at forge fitness.

## METHODOLOGY AND RESULTS

The south end of four beams was measured using a pin type moisture meter calibrated for wood materials. Each beam was measured in four locations, two on the side, and two on the bottom of the beam. In total 16 measurements were taken.

All 16 measurements were between 9% and 13.5%. Measurements were intentionally taken on what appeared to be a water stain from a previous roof leak, but moisture content was still within the 9% to 13.5% range. All locations were measured with ¼" pin depth and 2" pin depth. Pin depth did not increase or decrease the observed moisture content.


***Figure 1: Beams were measured in two locations on the sides of the beams and two locations on the bottom of the beam.***

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***Figure 2: Location of moisture content testing on glulam beams.***

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**DISCUSSION**

Due to the pool below the mid span of the beams and ceiling fans along the north side of the pool the midpoint and north end of the beams were not measured. Given that all the beams are located within the same ambient environment and relatively small range of observed moisture content, the moisture content within the beams is likely consistent with a range from 9% to 13.5%.

Respectfully Submitted,
**GeoTest Services, Inc.**

Chad Herrick, PE
Project Engineer, Building Science Division