

Wallace Design Collective, PC

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Approved

☐Approved as Noted

☐Revise as Noted and Resubmit

☐Rejected - Resubmit as Specified

By: **AJG**
Date: **06/03/2024**

Review is only for general conformance with the Contract Documents and design concept of the Project. Review does not authorize extra costs associated with deviations from the Contract Documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the Contract Documents and Contract Provisions. The Contractor remains responsible for selecting fabrication processes, for techniques of construction, confirming and correlating all quantities and dimensions, for coordinating his work with other trades, and for compliance with all applicable laws, regulations, and codes.

Airmen Dormitory - Bldg. 854

Little Rock A.F.B, Jacksonville, AR 72099

Wall and Diaphragm Strengthening Utilizing the Tyfo® FRP Systems

GENERAL NOTES:

SURFACE PREPARATION (CONCRETE SURFACES)

1. Ensure all structural cracks, spalls, damaged and unsound concrete are repaired with conventional methods to create a flat or slightly convex surface (by others).

2. Surfaces shall be prepared for bonding by means of abrasive blasting or grinding to remove existing laitance and expose aggregate [minimum ICRI CSP-3 concrete surface profile].

3. The surface to receive the composite shall be free from fins, sharp edges and protrusions that will cause voids behind the installed composite or that, in the opinion of the Engineer of Record, will damage the fibers.

4. For drilling anchor holes or creating penetrations, scanning steel rebar / tendons shall be done (by others) to avoid damaging steel reinforcement.

5. The surfaces to receive the composite shall have no free moisture at the time of application.

6. All contact surfaces shall be cleaned by hand, vacuum or compressed air.
5. Clean anchor holes with a steel bristle pipe brush equal to or greater than the concrete bit size (perform 5 insertions minimum).

6. Remove dust and debris created by anchor hole drilling and grinding with HEPA filtration vacuum equipment.

7. Repeat the previous two anchor installation/cleaning steps until all holes are created.

8. Protect areas adjacent to surfaces that will receive composite (e.g. prevent epoxy staining or contamination).

9. Apply one prime coat of epoxy resin to the substrate (2 mil Typ.). Allow sufficient time for primer to become tacky to the touch or to soak into the substrate and create a damp surface with no standing liquid.

10. Apply a uniform layer of thickened Tyfo® S Epoxy (15-30 mil Typ.) to prepare for bonding composite material and to fill uneven surfaces (up to 1.5" bug holes). Ensure that out of plane deviations are less than one inch per foot.

SURFACE PREPARATION (MASONRY SURFACES)

1. Take photos of existing damage or irregularities for each masonry wall. Consult with Fyfe & SEOR to determine required surface preparation for existing masonry substrates. Damaged or deteriorating grout lines may require re-pointing prior to installation of the Tyfo® FRP systems.

2. Restore masonry substrate to original condition (if required) to provide a convex, smooth surface, free of voids, sharp edges, or ridges. Grout lines that are in good condition and less than 1/2" deep can be smoothed out with thickened Tyfo® S epoxy prior to FRP installation.

3. Mark perimeter of areas to receive composite strengthening. The perimeter lines should extend 1-2" beyond the exact fabric placement to ensure fabric edges are detailed properly.

4. Prepare all marked surfaces for bonding by means of abrasive blasting or griding to remove existing laitance and roughen surfaces.

5. All edges to be wrapped around shall be rounded to a minimum radius of 1/2".

6. All contact surfaces shall be cleaned by hand, HEPA vacuum, or compressed air until free of laitance, dust, and debris.
11. Apply saturated fabric to substrate by hand. Fiber waviness or skew cannot exceed one inch per foot. Ensure proper orientation of the fabric.

12. Pre-saturate composite anchors by hand in a bath. Installation of dry anchors is prohibited.

13. Fill the drilled hole min. 75% volume with thickened Tyfo® S epoxy prior to installation.

14. Embed saturated anchor (with insertion tool) to the specified depth. Maintain tension in the anchor with the insertion tool and splay free end of anchor as detailed.

15. Apply subsequent composite layers, continuously or spliced, over installed anchor until designed number of layers is achieved.

16. Using a roller or hand pressure, release or roll out entrapped air, and ensure that each individual layer is firmly embedded and adhered to the preceding layer or substrate.

17. Finish all overlaps, seams and edges with thickened Tyfo® S Epoxy. Thickened Tyfo® S Epoxy to extend 1-2" beyond fabric onto roughened surface.

Key-Coat "Finish" (Top of slab): Immediately apply a 15-to-20mil coat of thickened Tyfo® S epoxy to all exposed surfaces extending at least 1" (25mm) past all edges. Immediately broadcast 10-to-16 mesh coarse, washed, dry sand to all exposed surfaces. Immediately blow any excess sand via a portable blower forward into the wet coating and discard any excess/loose sand. Allow installation to cure, undisturbed for at least 48-hours prior to the application of flooring or roofing materials.

INSTALLATION

1. Verify ambient and concrete/masonry temperatures. No work shall proceed if the temperature of the concrete/masonry surface is less than 50°F or greater than 100°F or as specified on the epoxy component labels. Substrate shall be at least 5°F above the dew point.

2. Fabric shall be completely saturated prior to application to contact surface. Both the epoxy resin and fabric shall be measured accurately, combined, and applied uniformly at the rates shown on the product data sheets.

3. All cutting of fabrics, mixing of epoxy and combination thereof shall take place in a protected area away from critical structure functions and any electrical equipment.

4. Drill holes for fiber anchors with a rotary hammer drill and a carbide bit. Grind edges around anchor holes for smooth transitions. Scanning steel rebar / tendons shall be done (by others) to avoid damaging steel reinforcement.
18. At 75°F, allow a minimum cure time of 24 hours prior to the application of finishes. If after 72 hours the epoxy is cured, the surface must be roughened by hand sanding or brush blasting, prior to finishing. Cure is a function of the environment, and thus environmental conditions dictate the applications window.

19. Suggested finish: Two-coats of owner-approved acrylic paint. Finish requirements and color specified in the project specifications shall supersede Fyfe's suggested finish and the installer shall select a finish coat system to meet those requirements. The Fyfe Tyfo® FRP Systems are inert and, therefore, compatible with all finish coat systems. See general notes for proper surface preparation prior to coating.

Sheet Set	
Sheet 1	Title sheet & General Notes
Sheet 2	First Floor FRP Plan - West
Sheet 3	First Floor FRP Plan - East
Sheet 4	Second Floor FRP Plan - West
Sheet 5	Second Floor FRP Plan - East
Sheet 6	Third Floor FRP Plan - West
Sheet 7	Third Floor FRP Plan - East
Sheet 8	Masonry Wall FRP Details - Vertical FRP
Sheet 9	Masonry Wall FRP Details - Horizontal FRP
Sheet 10	Slab FRP Details

MATERIALS:

Tyfo® SCH-41 Uni-directional Carbon Fiber System

5/8" Dia. Tyfo® SCH Composite Anchors

7/8" Dia. Tyfo® SCH Composite Anchors

Tyfo® S Epoxy & Thickened Tyfo® S Epoxy

Thickened Tyfo® S Epoxy: Tyfo® S Epoxy thickened with Cab-o-sil TS-720, or another Fyfe-approved inert filler, to fill voids and provide a smooth base for applying the fiber-epoxy resin laminates. The amount of Cab-o-sil TS-720, or another Fyfe-approved inert filler, added shall not exceed 7% by weight and is field adjusted based on application and temperature.

10-16 Mesh, Coarse, Washed, Kiln-dried Sand.

GENERAL NOTE: The details in this shop drawing set are based on the project drawings and any verified site conditions prior to installation. Any site conditions that are not shown in these shop drawings which would impede or alter the installation of the Tyfo® Systems as detailed, shall be immediately communicated to Fyfe® company and/or the Engineer-of-Record. Do not proceed with any work at these locations until revised detailing is approved.

DISCLAIMER: Fyfe® company did not analyze the capacity of the existing structural members or its condition. The details and notes shown on these drawings are only relevant to and only intend for the specific Tyfo® products called out. In no event should these drawings or any details or notes herein be used without the specific Tyfo® products called out. Any use or reliance on these drawings or any details or notes herein without the specific Tyfo® products is strictly prohibited. Should other products be used on the project, these stamped drawings shall be considered null and void and FyfeFRP, LLC its employees, directors, and affiliates assume no liability with respect to such use. These stamped drawings do not in any way infer equivalency of any product(s) to that of the Tyfo® FRP systems shown. These stamped drawings do not imply the approval from any relevant authority having jurisdiction.

Revision No.	Revised By	Revision Date

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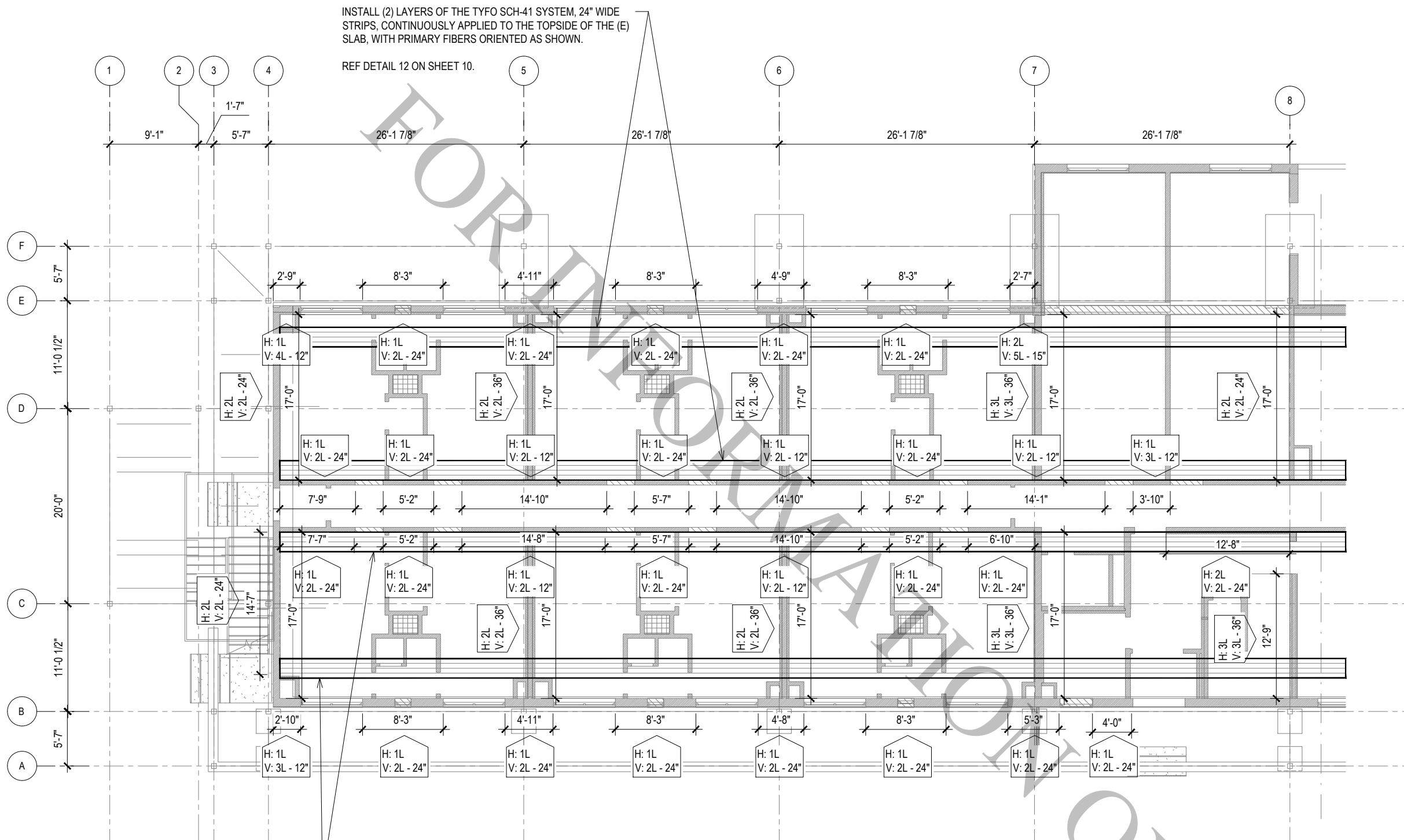
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Drafter:	MR	Orig. Date:	2024/05/17
Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 1 of 10	Title sheet & General Notes	



INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF DETAIL 12 ON SHEET 10.

SHEET NOTES:

- ALL DIMENSIONS SHOWN ON THE PLANS SHALL BE VERIFIED IN FIELD.
- TYFO SCH-41 FRP REINFORCEMENT SHALL BE APPLIED TO ONE FACE OF THE WALL. CONTRACTOR MAY APPLY FRP TO EITHER FACE OF THE WALL AS LONG AS IT IS BONDED TO THE STRUCTURAL 6" MASONRY BLOCK WALL. DO NOT APPLY FRP TO THE RED BRICK FACADE.
- APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
- VERTICAL TYFO SCH-41 REINFORCEMENT MUST BE CONTINUOUS FOR THE FULL HEIGHT OF THE BUILDING. THEREFORE, THE VERTICAL STRIPS MUST BE APPLIED ON ONE FACE FOR THE FULL HEIGHT OF THE WALL (LEVELS 1-3) AND MUST BE ALIGNED WITH THE VERTICAL STRIPS AT THE WALL ABOVE/BELOW.
- SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

LEGEND:

H: #L
V: #L - #"

H: #L - HORIZONTAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS SPACED 24" O.C. (FULL COVERAGE), APPLIED TO ONE FACE OF THE WALL, PRIMARY FIBERS ORIENTED HORIZONTALLY. SEE DETAIL 10 ON SHEET 9.

V: #L - #L - VERTICAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS APPLIED TO EACH WALL END ON ONE FACE OF THE WALL (REF. SHEET NOTE 4), PRIMARY FIBERS ORIENTED VERTICALLY. SEE DETAIL 7 ON SHEET 8.

1 First Floor FRP Plan - West
N.T.S.



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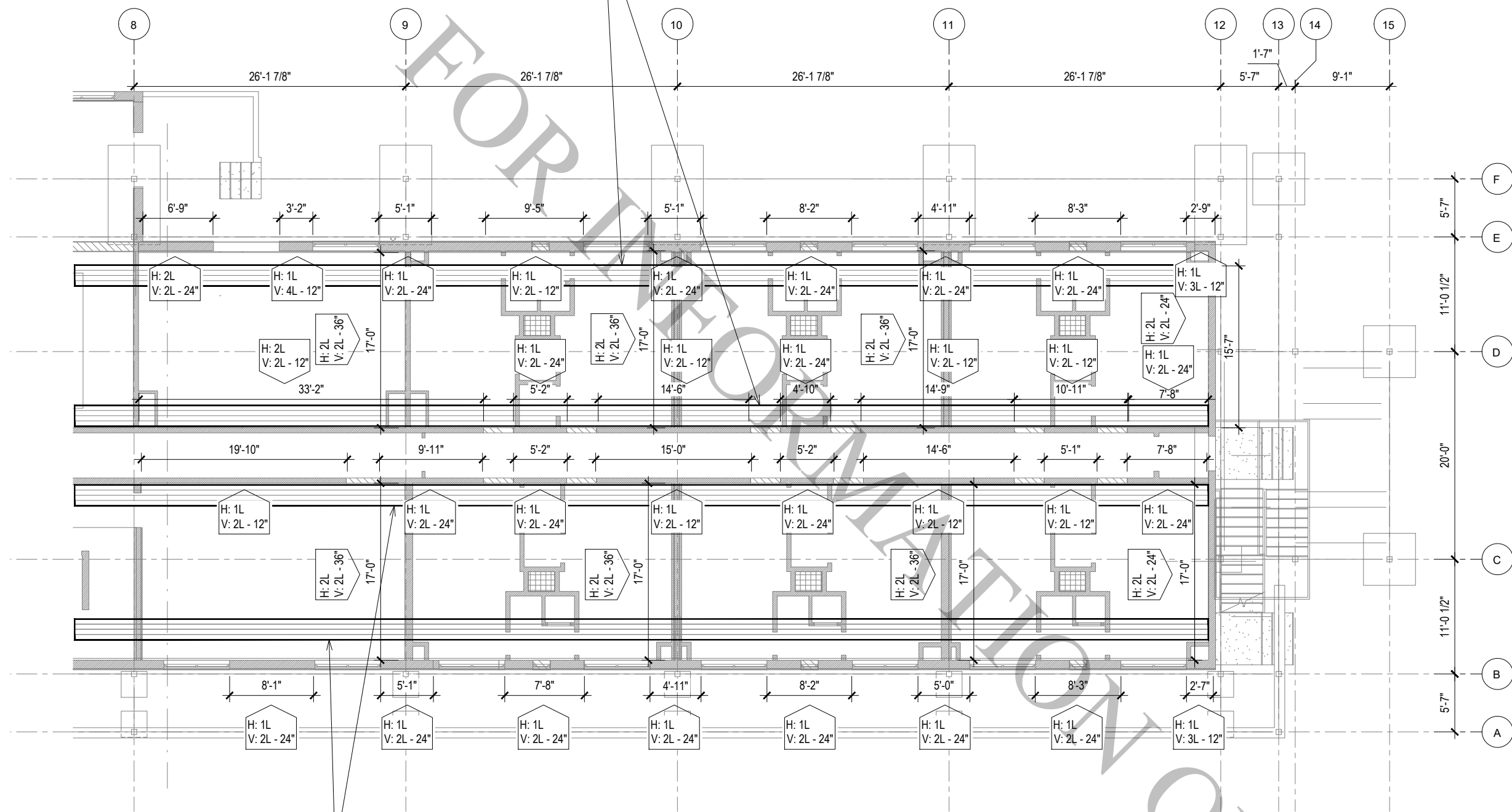


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Drafter:	MR	Orig. Date:	2024/05/17
Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 2 of 10	First Floor FRP Plan - West	

INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.



INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.

SHEET NOTES:

1. ALL DIMENSIONS SHOWN ON THE PLANS SHALL BE VERIFIED IN FIELD.
2. TYFO SCH-41 FRP REINFORCEMENT SHALL BE APPLIED TO ONE FACE OF THE WALL. CONTRACTOR MAY APPLY FRP TO EITHER FACE OF THE WALL AS LONG AS IT IS BONDED TO THE STRUCTURAL 6" MASONRY BLOCK WALL. DO NOT APPLY FRP TO THE RED BRICK FACADE.
3. APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
4. VERTICAL TYFO SCH-41 REINFORCEMENT MUST BE CONTINUOUS FOR THE FULL HEIGHT OF THE BUILDING. THEREFORE, THE VERTICAL STRIPS MUST BE APPLIED ON ONE FACE FOR THE FULL HEIGHT OF THE WALL (LEVELS 1-3) AND MUST BE ALIGNED WITH THE VERTICAL STRIPS AT THE WALL ABOVE/BELOW.
5. SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

LEGEND:

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V: #L - #"

H: #L - HORIZONTAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS SPACED 24" O.C. (FULL COVERAGE), APPLIED TO ONE FACE OF THE WALL, PRIMARY FIBERS ORIENTED HORIZONTALLY. SEE DETAIL 10 ON SHEET 9.

V: #L - #L - VERTICAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, # WIDE STRIPS APPLIED TO EACH WALL END ON ONE FACE OF THE WALL (REF. SHEET NOTE 4), PRIMARY FIBERS ORIENTED VERTICALLY. SEE DETAIL 7 ON SHEET 8.

2 First Floor FRP Plan - East
N.T.S.



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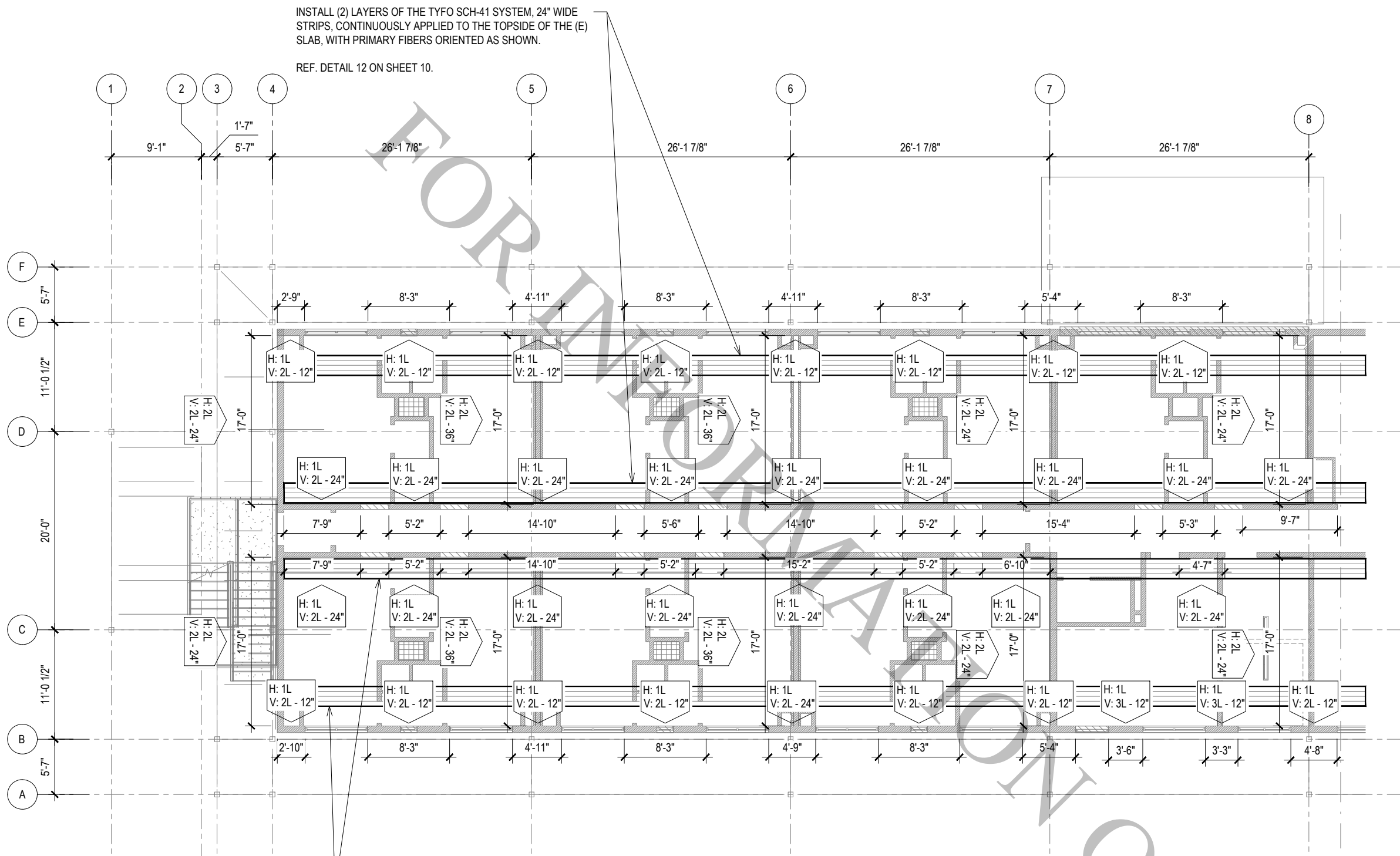
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Dwg. No.:	Sheet 3 of 10	First Floor FRP Plan - East	



INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.

SHEET NOTES:

- ALL DIMENSIONS SHOWN ON THE PLANS SHALL BE VERIFIED IN FIELD.
- TYFO SCH-41 FRP REINFORCEMENT SHALL BE APPLIED TO ONE FACE OF THE WALL. CONTRACTOR MAY APPLY FRP TO EITHER FACE OF THE WALL AS LONG AS IT IS BONDED TO THE STRUCTURAL 6" MASONRY BLOCK WALL. DO NOT APPLY FRP TO THE RED BRICK FACADE.
- APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
- VERTICAL TYFO SCH-41 REINFORCEMENT MUST BE CONTINUOUS FOR THE FULL HEIGHT OF THE BUILDING. THEREFORE, THE VERTICAL STRIPS MUST BE APPLIED ON ONE FACE FOR THE FULL HEIGHT OF THE WALL (LEVELS 1-3) AND MUST BE ALIGNED WITH THE VERTICAL STRIPS AT THE WALL ABOVE/BELOW.
- SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

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3 Second Floor FRP Plan - West
N.T.S.



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Dwg. No.:	Sheet 4 of 10	Second Floor FRP Plan - West	

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Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 5 of 10	Second Floor FRP Plan -East	

INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.

INSTALL (2) LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.

- SHEET NOTES:
1.

ALL DIMENSIONS SHOWN ON THE PLANS SHALL BE VERIFIED IN FIELD.
2.

TYFO SCH-41 FRP REINFORCEMENT SHALL BE APPLIED TO ONE FACE OF THE WALL. CONTRACTOR MAY APPLY FRP TO EITHER FACE OF THE WALL AS LONG AS IT IS BONDED TO THE STRUCTURAL 6" MASONRY BLOCK WALL. DO NOT APPLY FRP TO THE RED BRICK FACADE.
3.

APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
4.

VERTICAL TYFO SCH-41 REINFORCEMENT MUST BE CONTINUOUS FOR THE FULL HEIGHT OF THE BUILDING. THEREFORE, THE VERTICAL STRIPS MUST BE APPLIED ON ONE FACE FOR THE FULL HEIGHT OF THE WALL (LEVELS 1-3) AND MUST BE ALIGNED WITH THE VERTICAL STRIPS AT THE WALL ABOVE/BELOW.
5.

SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

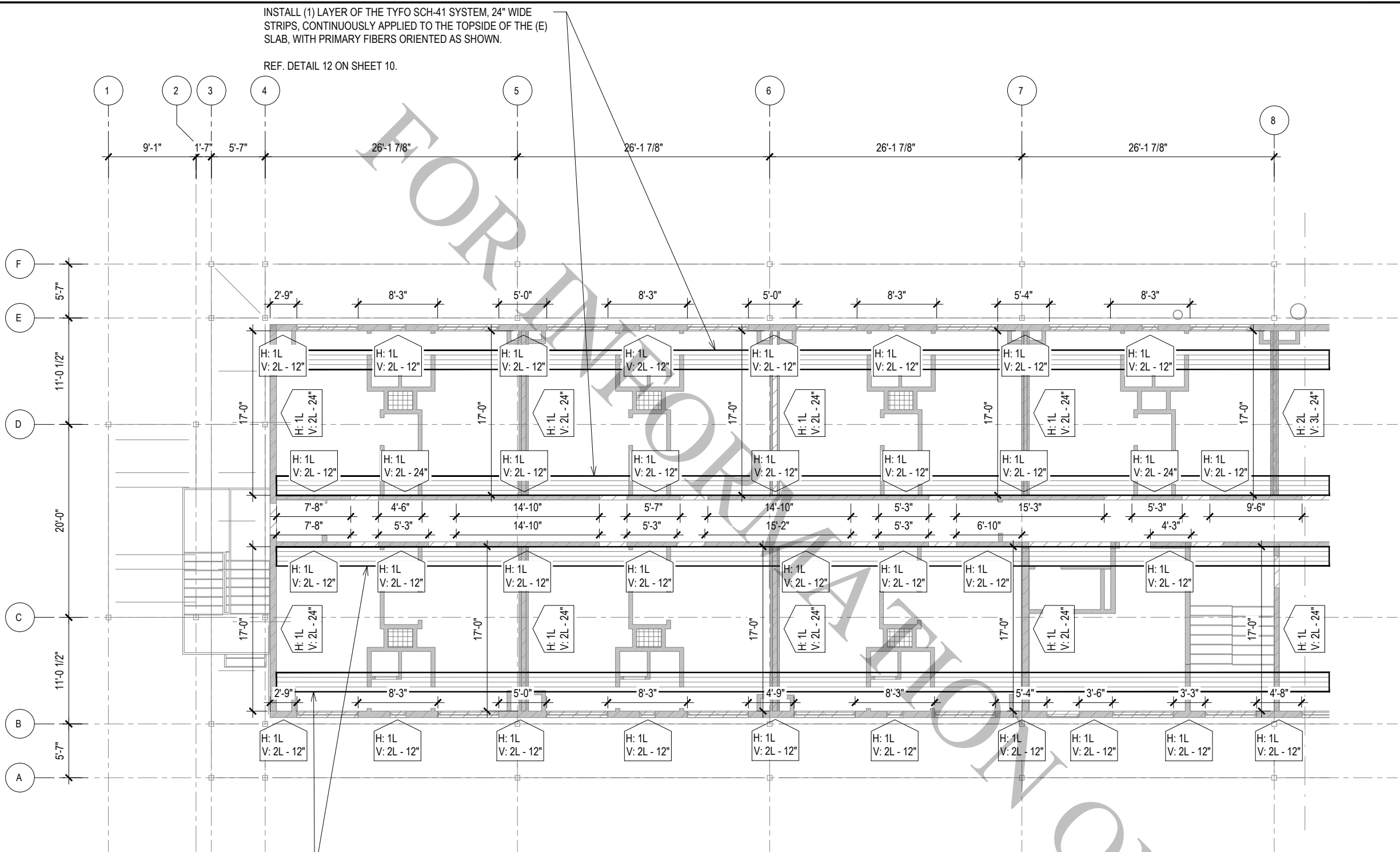
LEGEND:

H: #L
V: #L - #"

H: #L - HORIZONTAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS SPACED 24" O.C. (FULL COVERAGE), APPLIED TO ONE FACE OF THE WALL, PRIMARY FIBERS ORIENTED HORIZONTALLY. SEE DETAIL 10 ON SHEET 9.

V: #L - #"

V: #L - VERTICAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS APPLIED TO EACH WALL END ON ONE FACE OF THE WALL (REF. SHEET NOTE 4), PRIMARY FIBERS ORIENTED VERTICALLY. SEE DETAIL 7 ON SHEET 8.



INSTALL (1) LAYER OF THE TYFO SCH-41 SYSTEM, 24\"/>

REF. DETAIL 12 ON SHEET 10.

- SHEET NOTES:**
- ALL DIMENSIONS SHOWN ON THE PLANS SHALL BE VERIFIED IN FIELD.
 - TYFO SCH-41 FRP REINFORCEMENT SHALL BE APPLIED TO ONE FACE OF THE WALL. CONTRACTOR MAY APPLY FRP TO EITHER FACE OF THE WALL AS LONG AS IT IS BONDED TO THE STRUCTURAL 6\"/>
 - APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
 - VERTICAL TYFO SCH-41 REINFORCEMENT MUST BE CONTINUOUS FOR THE FULL HEIGHT OF THE BUILDING. THEREFORE, THE VERTICAL STRIPS MUST BE APPLIED ON ONE FACE FOR THE FULL HEIGHT OF THE WALL (LEVELS 1-3) AND MUST BE ALIGNED WITH THE VERTICAL STRIPS AT THE WALL ABOVE/BELOW.
 - SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

- LEGEND:**
- H: #L
V: #L - #"
- H: #L - HORIZONTAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24\"/>
- V: #L - #\"/>

5 Third Floor FRP Plan - West
N.T.S.

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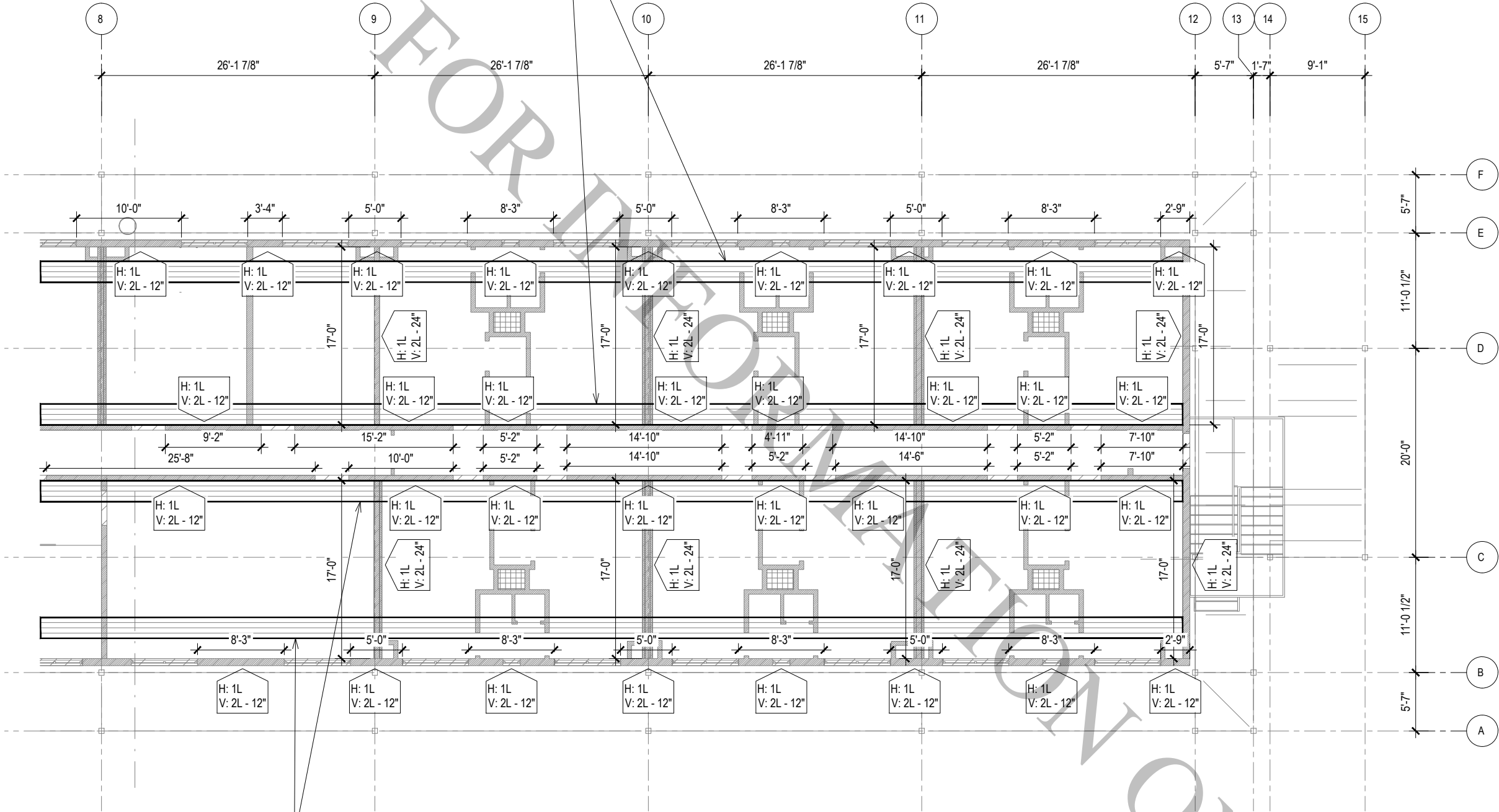


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Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 6 of 10	Third Floor FRP Plan - West	

INSTALL (1) LAYER OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

REF. DETAIL 12 ON SHEET 10.



INSTALL (1) LAYER OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS, CONTINUOUSLY APPLIED TO THE TOPSIDE OF THE (E) SLAB, WITH PRIMARY FIBERS ORIENTED AS SHOWN.

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SHEET NOTES:

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- APPLY "KEY COAT" OF THICKENED TYFO S EPOXY & SAND PER GENERAL NOTES OVER TOPSIDE OF CONCRETE SLAB FRP.
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- SEE SHEETS 8 THROUGH 10 FOR TYPICAL DETAILS.

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H: #L - HORIZONTAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS SPACED 24" O.C. (FULL COVERAGE), APPLIED TO ONE FACE OF THE WALL, PRIMARY FIBERS ORIENTED HORIZONTALLY. SEE DETAIL 10 ON SHEET 9.

V: #L - #L - VERTICAL FRP REINFORCEMENT - # LAYERS OF THE TYFO SCH-41 SYSTEM, 24" WIDE STRIPS APPLIED TO EACH WALL END ON ONE FACE OF THE WALL (REF. SHEET NOTE 4), PRIMARY FIBERS ORIENTED VERTICALLY. SEE DETAIL 7 ON SHEET 8.

6 Third Floor FRP Plan - East
N.T.S.



Revision No.	Revised By	Revision Date

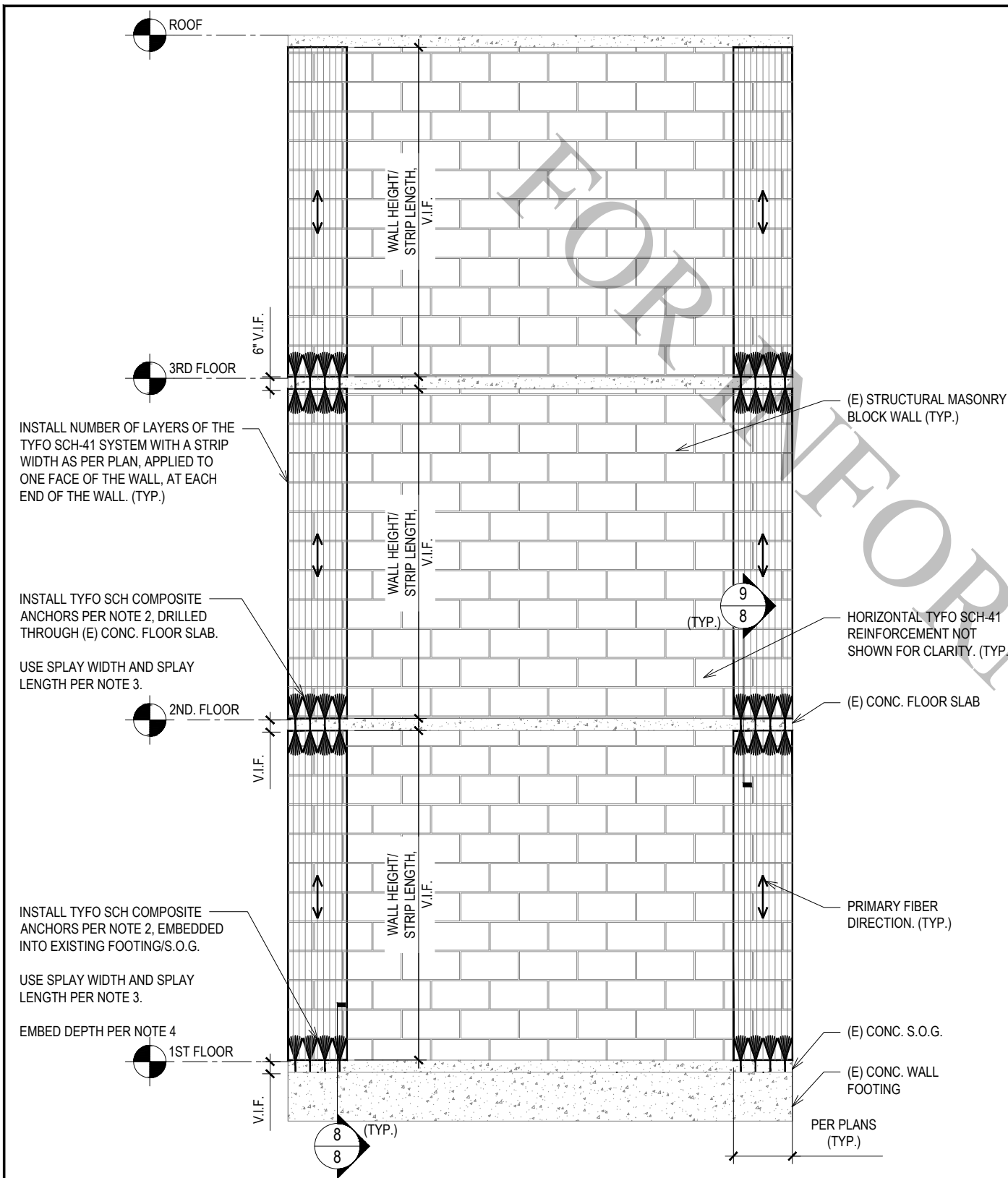
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Dwg. No.:	Sheet 7 of 10	Third Floor FRP Plan - East	



INSTALL NUMBER OF LAYERS OF THE TYFO SCH-41 SYSTEM WITH A STRIP WIDTH AS PER PLAN, APPLIED TO ONE FACE OF THE WALL, AT EACH END OF THE WALL. (TYP.)

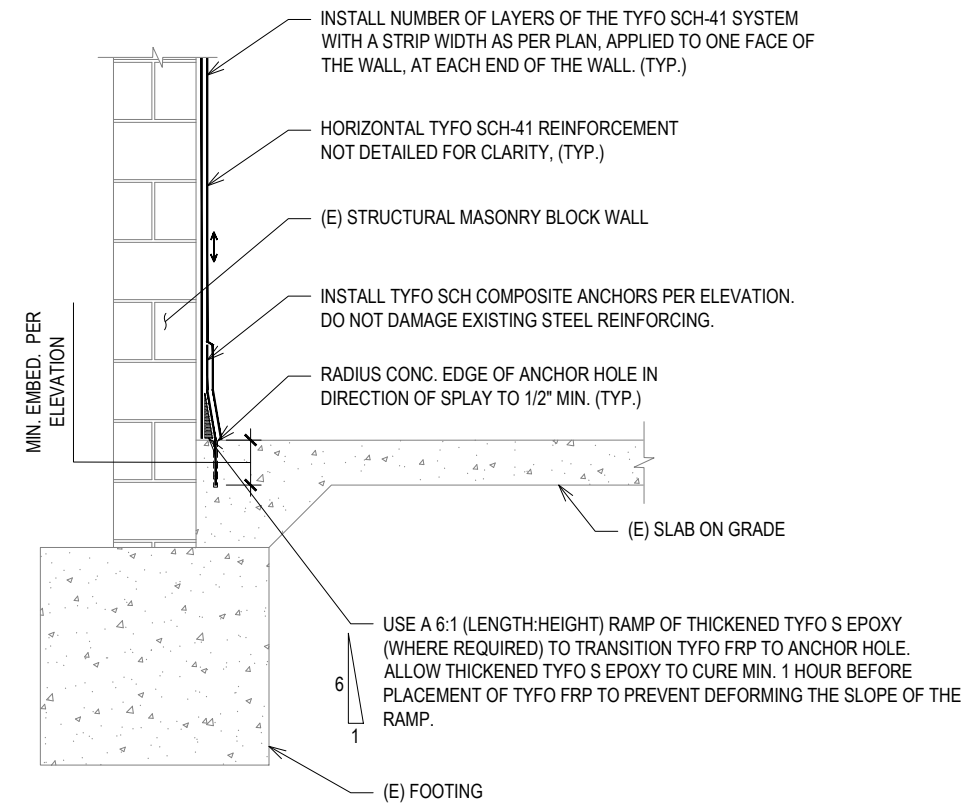
INSTALL TYFO SCH COMPOSITE ANCHORS PER NOTE 2, DRILLED THROUGH (E) CONC. FLOOR SLAB.
USE SPLAY WIDTH AND SPLAY LENGTH PER NOTE 3.

INSTALL TYFO SCH COMPOSITE ANCHORS PER NOTE 2, EMBEDDED INTO EXISTING FOOTING/S.O.G.
USE SPLAY WIDTH AND SPLAY LENGTH PER NOTE 3.

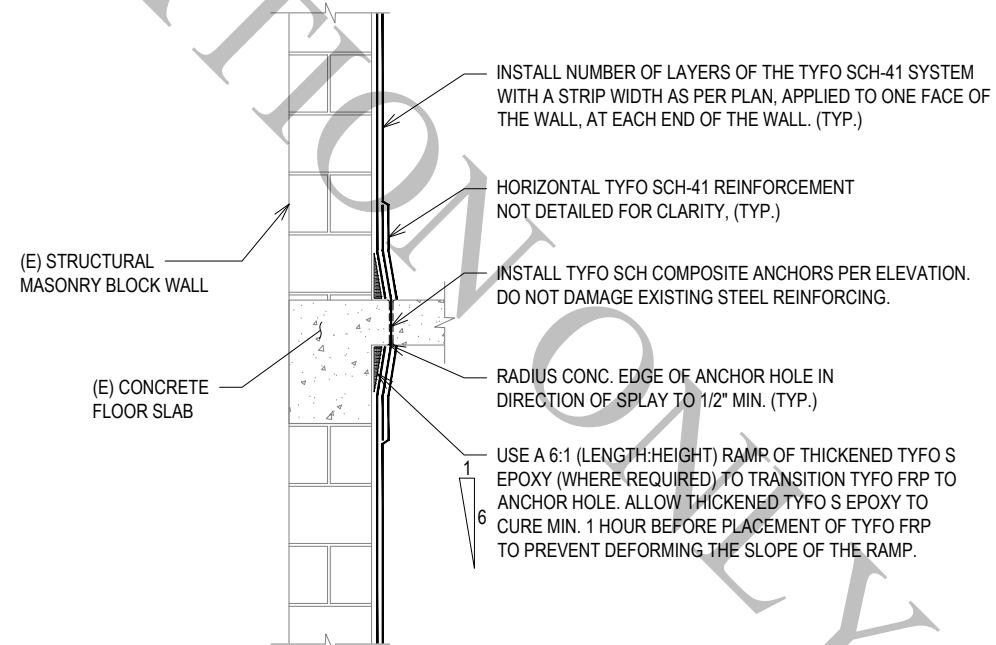
EMBED DEPTH PER NOTE 4

- SHEET NOTES:**
1. INSTALL VERTICAL TYFO SCH-41 PRIOR TO HORIZONTAL TYFO SCH-41.
 2. INSTALL 5/8" DIA. ANCHORS SPACED MAXIMUM 6" ON CENTER FOR (2) LAYERS OF VERTICAL REINFORCING & INSTALL 7/8" DIA. ANCHORS SPACED MAXIMUM 6" ON CENTER FOR (3, 4, OR 5) LAYERS OF VERTICAL REINFORCING.
 3. USE 8" SPLAY WIDTH FOR BOTH ANCHOR DIAMETERS. NOTE THAT ANCHOR SPLAYS WILL OVERLAP EACH OTHER BY 2" TO MEET MIN. 8" SPLAY WIDTH. USE 12" SPLAY LENGTH FOR 5/8" DIA. ANCHORS. USE 16" SPLAY LENGTH FOR 7/8" DIA. ANCHORS.
 4. USE 6" MIN. EMBEDMENT DEPTH FOR 5/8" ANCHORS. USE 8" MIN. EMBEDMENT DEPTH FOR 7/8" ANCHORS.

7 Typical Wall Elevation - Vertical FRP
N.T.S.



8 Typical Embedded Anchor Section
N.T.S.



9 Typical Through Anchor Section
N.T.S.

Revision No.	Revised By	Revision Date

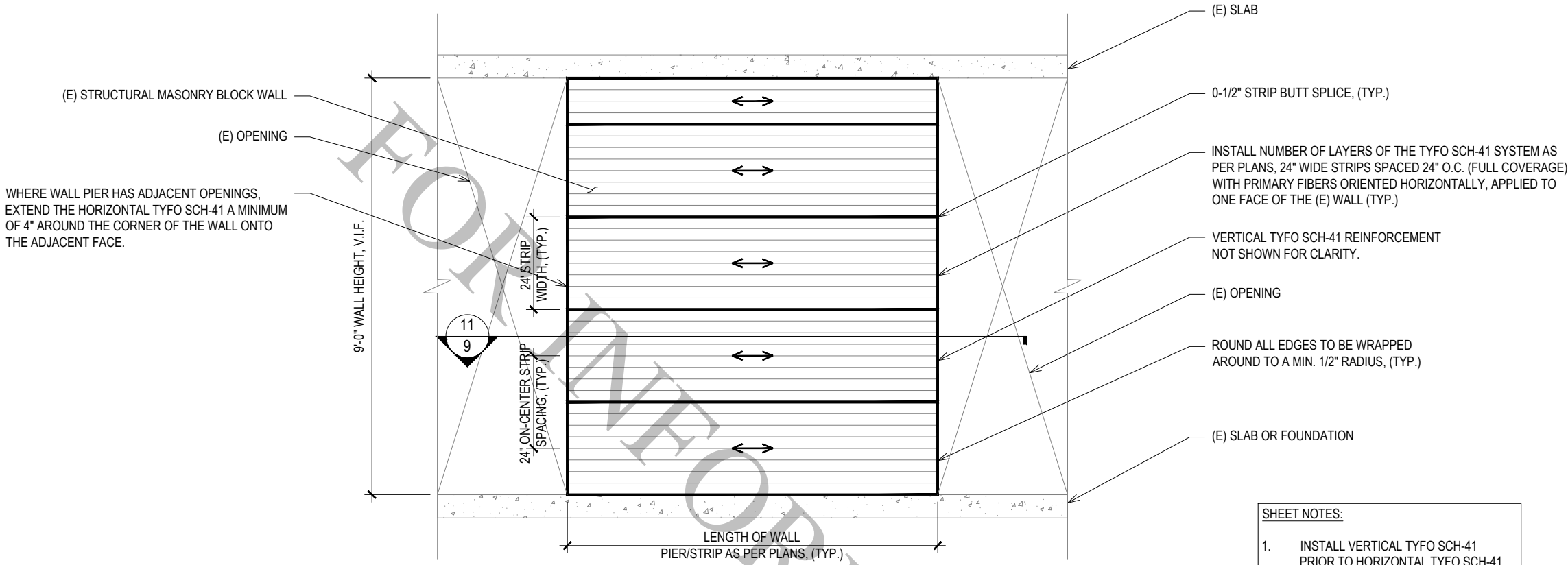
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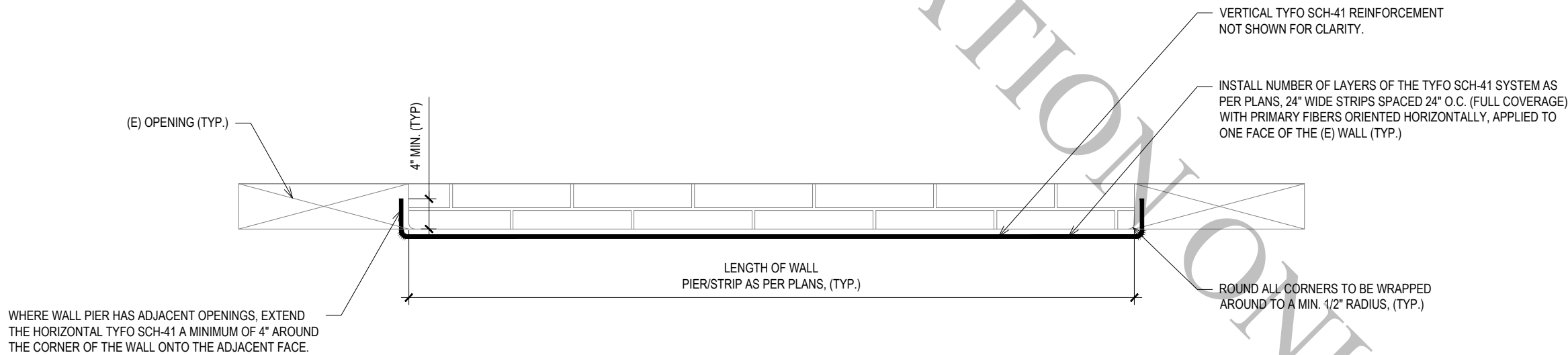


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Drafter:	MR	Orig. Date:	2024/05/17
Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 8 of 10	Masonry Wall FRP Details - Vertical FRP	



10 Typical Wall Elevation - Horizontal FRP
N.T.S.



11 Typical Wall Section - Horizontal FRP
N.T.S.

Revision No.	Revised By	Revision Date

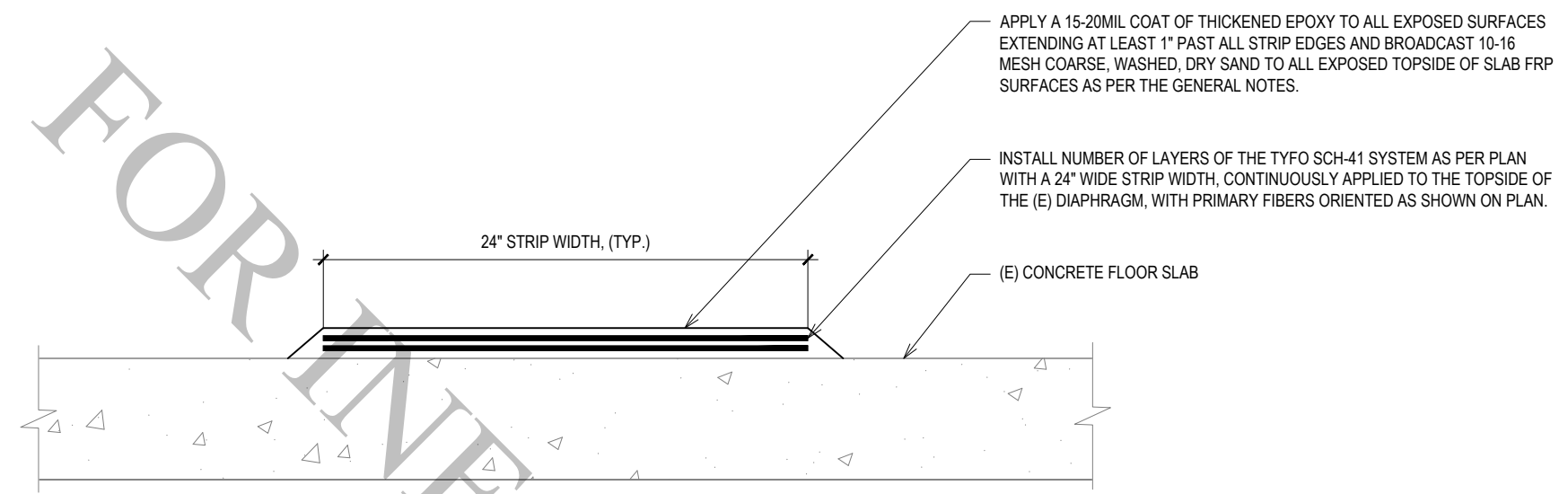
Engineer Stamp

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Jacksonville, AR
72099
Wall and Diaphragm
Strengthening

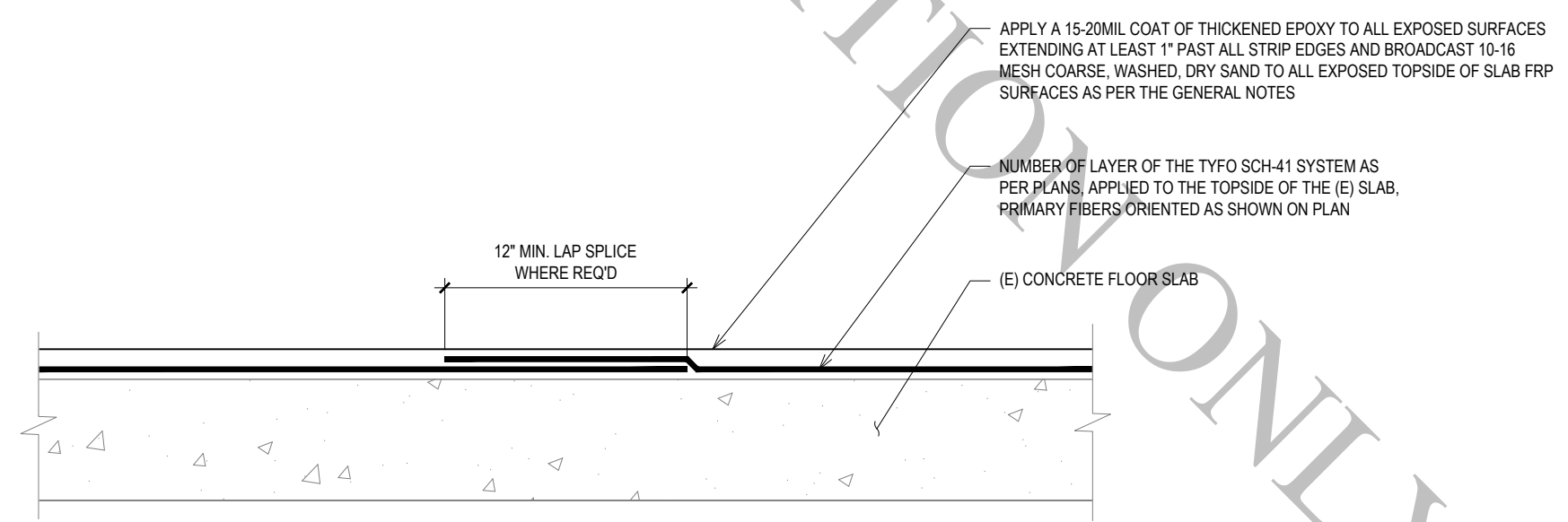
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Engineer:	S.RUPP	Rev. Date:	
Dwg. No.:	Sheet 9 of 10	Masonry Wall FRP Details - Horizontal FRP	



12 Typical Chord/Slab Cross Section
N.T.S.



13 Typical Lap Splice Detail
N.T.S.

Revision No.	Revised By	Revision Date
Engineer Stamp		
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Drafter:	MR	Orig. Date: 2024/05/17
Engineer:	S.RUPP	Rev. Date:
Dwg. No.:	Sheet 10 of 10	Slab FRP Details

Airmen Dormitory - Building 854 Jacksonville, AR 72099

Structural Engineer of Record:

Wallace Design Collective
1703 Wyandotte Street, Suite 200
Kansas City, Missouri 64108

Calculations:

1. Masonry Wall In-Plane Shear Calculations
2. Masonry Wall In-Plane Flexure Calculations
3. Concrete Slab Chord Calculations

Wallace Design Collective, PC	
☒	Approved
☐	Approved as Noted
☐	Revise as Noted and Resubmit
☐	Rejected - Resubmit as Specified
By: <u>AJG</u>	
Date: <u>06/03/2024</u>	

Review is only for general conformance with the Contract Documents and design concept of the Project. Review does not authorize extra costs associated with deviations from the Contract Documents. Markings or comments shall not be construed as relieving the Contractor from compliance with the Contract Documents and Contract Provisions. The Contractor remains responsible for selecting fabrication processes, for techniques of construction, confirming and correlating all quantities and dimensions, for coordinating his work with other trades, and for compliance with all applicable laws, regulations, and codes.

Disclaimer: Fyfe Company did not analyze the capacity of the existing structural members or its condition, nor did Fyfe Company provide the loading demand values used for the FRP design. The composite system was designed only to provide the additional capacity as noted in the calculations. Additionally, thermal gradation effects were not considered in the FRP design.

REFERENCES

1. ACI 440.2R-17. Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures. 2017
2. ASCE Standard, ASCE/SEI, 41-17: Seismic Evaluation and Retrofit of Existing Buildings. American Society of Civil Engineers, 2017.
3. FyfeFRP, LLC. Design Manual for the Tyfo System. Version 11. May 2022.

Airmen Dormitory - Building 854

Masonry Wall In-Plane Shear Strengthening

1.0 DESIGN GOAL

Design the Tyfo FRP System to provide shear capacity to existing unreinforced masonry block walls, as specified by Wallace Design Collective Structural Engineers.

2.0 GENERAL NOTES AND ASSUMPTIONS

1. The ultimate design strain of the Tyfo SCH-41 carbon composite system is 0.009 in/in. However, the maximum effective strain in the FRP system shall conservatively be taken as 0.0015 in/in. for one-sided wall shear strengthening.
2. Assumed strength reduction factor (ϕ) can be taken to unity (1.0) for seismic design per ASCE-41.
3. Fyfe has not evaluated the existing structural capacity of the masonry block walls and therefore has not evaluated alternate failure modes that may occur prior to the FRP system reaching its allowable design strength. The FRP system is only designed to provide additional shear capacity to the masonry block walls acting as a horizontally-oriented (in-plane shear) tension member.
4. The following calculation pertains to wall location ID 1. A summary of all wall strengthening calculations is presented in the conclusion (section 5.0) and each calculation in the conclusion follows the procedure set forth in sections 3.0-4.0.
5. Location ID plans are attached to the back end of all Fyfe Calculations.

3.0 MATERIAL PROPERTIES OF THE TYFO SCH-41 CARBON COMPOSITE SYSTEM

Ultimate Properties:

$C_E := 0.95$	environmental reduction factor for interior environment (ACI 440.2R-17 Table 9.4)
$f_{fu} := 131 \cdot \text{ksi}$	ultimate tensile stress
$f_f := C_E \cdot f_{fu} = 124.5 \text{ ksi}$	design ultimate tensile stress (eq. 9.4a)
$\epsilon_{fu} := 0.009 \frac{\text{in}}{\text{in}}$	ultimate tensile strain
$\epsilon_f := C_E \cdot \epsilon_{fu} = 0.0086 \frac{\text{in}}{\text{in}}$	design ultimate tensile strain (eq. 9.4b)
$E_f := \frac{f_f}{\epsilon_f} = 14555.6 \text{ ksi}$	ultimate modulus of elasticity
$E_f := 12660 \text{ ksi}$	design modulus of elasticity
$t_f := 0.04 \cdot \text{in}$	thickness per layer

4.0 SHEAR STRENGTHENING CALCULATIONS (LOCATION ID 1)

$\phi := 1$ strength reduction factor (taken to unity for seismic design per ASCE-41)

$V_{req} := 20 \text{ kip}$ required additional shear capacity

$n := 1$ number of layers of FRP

The effective strain in the FRP is taken as 0.0015 in/in. for one-sided wall shear strengthening applications.

$\varepsilon_{fe} := 0.0015 \frac{\text{in}}{\text{in}}$ effective design strain

Effective Shear Capacity

$f_{fe} := E_f \cdot \varepsilon_{fe} = 19 \text{ ksi}$ effective FRP design stress

$w_f := 24 \cdot \text{in}$ width of FRP strips

$s_f := 24 \cdot \text{in}$ spacing of FRP (full coverage)

$l_w := 2.75 \text{ ft}$ wall length

$\phi V_f := \phi \cdot n \cdot t_f \cdot f_{fe} \cdot l_w \cdot \frac{w_f}{s_f} = 25.1 \text{ kip}$ factored shear capacity provided by FRP

$DCR := \frac{V_{req}}{\phi V_f} = 0.8$

5.0 CONCLUSION

Install one layer of the Tyfo SCH-41 system, 24" wide strips spaced 24" on center (100% coverage), with primary fibers oriented in the direction parallel to the applied shear force to meet a 20 kip shear demand.

The following table summarizes all wall strengthening locations. Each calculation summarized in the following table conforms to the calculation procedure set forth in sections 3.0-4.0 for Masonry Wall In-Plane Shear Strengthening.

Wall Properties			Fiber Properties							
Location ID #	Vreq (kip)	L (ft)	w _f (in)	# layers	s _f (in)	A _f (sq in)	ε _{fe}	f _{fe} (ksi)	φV _f (kip)	DCR
1	20	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.80
2	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
3	41	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.90
4	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
5	41	4.83	24	1	24	0.96	0.0015	18.99	44.06	0.93
6	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
7	30	2.58	24	2	24	1.92	0.0015	18.99	47.10	0.64
8	200	16.92	24	2	24	1.92	0.0015	18.99	308.40	0.65
9	274	16.83	24	2	24	1.92	0.0015	18.99	306.88	0.89
10	258	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.83
11	322	16.92	24	3	24	2.88	0.0015	18.99	462.60	0.70
12	227	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.73
13	30	3.83	24	1	24	0.96	0.0015	18.99	34.94	0.86
14	112	14.08	24	1	24	0.96	0.0015	18.99	128.37	0.87
15	41	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.86
16	118	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.87
17	44	5.67	24	1	24	0.96	0.0015	18.99	51.65	0.85
18	118	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.87
19	42	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.89
20	63	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.89
21	63	7.58	24	1	24	0.96	0.0015	18.99	69.12	0.91
22	42	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.91
23	117	14.67	24	1	24	0.96	0.0015	18.99	133.69	0.88
24	44	5.67	24	1	24	0.96	0.0015	18.99	51.65	0.85
25	117	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.87
26	42	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.88
27	57	6.83	24	1	24	0.96	0.0015	18.99	62.29	0.92
28	137	12.67	24	2	24	1.92	0.0015	18.99	230.92	0.59
29	204	19.17	24	2	24	1.92	0.0015	18.99	349.42	0.58
30	274	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.88
31	258	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.83

32	322	17.00	24	3	24	2.88	0.0015	18.99	464.88	0.69
33	301	12.83	24	3	24	2.88	0.0015	18.99	350.94	0.86
34	33	4.00	24	1	24	0.96	0.0015	18.99	36.46	0.91
35	44	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.92
36	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
37	39	4.67	24	1	24	0.96	0.0015	18.99	42.54	0.92
38	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
39	41	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.90
40	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
41	19	2.83	24	1	24	0.96	0.0015	18.99	25.83	0.74
42	64	6.83	24	2	24	1.92	0.0015	18.99	124.57	0.51
43	27	3.25	24	1	24	0.96	0.0015	18.99	29.62	0.91
44	42	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.89
45	54	9.50	24	1	24	0.96	0.0015	18.99	86.59	0.62
46	41	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.88
47	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
48	41	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.90
49	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
50	19	2.83	24	1	24	0.96	0.0015	18.99	25.83	0.74
51	243	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.78
52	259	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.84
53	275	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.89
54	201	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.65
55	64	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.91
56	41	10.92	24	1	24	0.96	0.0015	18.99	99.51	0.41
57	117	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.87
58	39	4.83	24	1	24	0.96	0.0015	18.99	44.06	0.89
59	118	14.58	24	1	24	0.96	0.0015	18.99	132.93	0.89
60	41	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.86
61	337	33.17	24	2	24	1.92	0.0015	18.99	604.64	0.56
62	159	19.92	24	1	24	0.96	0.0015	18.99	181.54	0.88
63	79	9.92	24	1	24	0.96	0.0015	18.99	90.39	0.87
64	41	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.87

65	117	15.00	24	1	24	0.96	0.0015	18.99	136.73	0.86
66	41	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.87
67	115	14.50	24	1	24	0.96	0.0015	18.99	132.17	0.87
68	41	8.00	24	1	24	0.96	0.0015	18.99	72.92	0.56
69	64	7.67	24	1	24	0.96	0.0015	18.99	69.88	0.92
70	205	16.92	24	2	24	1.92	0.0015	18.99	308.40	0.66
71	275	16.92	24	2	24	1.92	0.0015	18.99	308.40	0.89
72	259	17.17	24	2	24	1.92	0.0015	18.99	312.96	0.83
73	243	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.78
74	67	8.08	24	1	24	0.96	0.0015	18.99	73.68	0.91
75	41	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.88
76	49	7.67	24	1	24	0.96	0.0015	18.99	69.88	0.70
77	41	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.90
78	54	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.72
79	36	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.79
80	59	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.78
81	15	2.58	24	1	24	0.96	0.0015	18.99	23.55	0.64
82	12	2.67	24	1	24	0.96	0.0015	18.99	24.31	0.49
83	35	8.33	24	1	24	0.96	0.0015	18.99	75.96	0.46
84	26	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.57
85	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
86	26	4.92	24	1	24	0.96	0.0015	18.99	44.82	0.58
87	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
88	28	5.33	24	1	24	0.96	0.0015	18.99	48.61	0.58
89	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
90	170	16.92	24	2	24	1.92	0.0015	18.99	308.40	0.55
91	237	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.76
92	224	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.72
93	211	17.08	24	2	24	1.92	0.0015	18.99	311.44	0.68
94	198	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.64
95	72	9.58	24	1	24	0.96	0.0015	18.99	87.35	0.82
96	40	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.84
97	116	15.25	24	1	24	0.96	0.0015	18.99	139.01	0.83

98	40	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.84
99	112	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.83
100	42	5.33	24	1	24	0.96	0.0015	18.99	48.61	0.86
101	112	15.00	24	1	24	0.96	0.0015	18.99	136.73	0.82
102	40	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.86
103	60	7.67	24	1	24	0.96	0.0015	18.99	69.88	0.86
104	60	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.85
105	40	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.85
106	112	15.00	24	1	24	0.96	0.0015	18.99	136.73	0.82
107	40	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.85
108	115	15.17	24	1	24	0.96	0.0015	18.99	138.25	0.83
109	40	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.86
110	55	6.75	24	1	24	0.96	0.0015	18.99	61.53	0.89
111	41	4.58	24	1	24	0.96	0.0015	18.99	41.78	0.98
112	187	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.60
113	211	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.68
114	224	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.72
115	237	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.76
116	176	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.57
117	12	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.48
118	35	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.47
119	26	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.57
120	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
121	25	4.58	24	1	24	0.96	0.0015	18.99	41.78	0.60
122	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
123	28	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.59
124	18	3.50	24	1	24	0.96	0.0015	18.99	31.90	0.56
125	17	3.25	24	1	24	0.96	0.0015	18.99	29.62	0.57
126	24	4.67	24	1	24	0.96	0.0015	18.99	42.54	0.56
127	52	9.92	24	1	24	0.96	0.0015	18.99	90.39	0.58
128	18	3.17	24	1	24	0.96	0.0015	18.99	28.86	0.62
129	26	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.57
130	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45

131	26	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.57
132	34	8.17	24	1	24	0.96	0.0015	18.99	74.44	0.46
133	26	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.57
134	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
135	12	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.48
136	172	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.55
137	237	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.76
138	224	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.72
139	211	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.68
140	70	9.67	24	1	24	0.96	0.0015	18.99	88.11	0.79
141	115	14.75	24	1	24	0.96	0.0015	18.99	134.45	0.86
142	39	5.08	24	1	24	0.96	0.0015	18.99	46.34	0.84
143	112	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.83
144	37	4.75	24	1	24	0.96	0.0015	18.99	43.30	0.85
145	112	14.75	24	1	24	0.96	0.0015	18.99	134.45	0.83
146	39	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.86
147	61	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.86
148	194	25.67	24	1	24	0.96	0.0015	18.99	233.96	0.83
149	76	9.75	24	1	24	0.96	0.0015	18.99	88.87	0.86
150	39	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.86
151	112	14.83	24	1	24	0.96	0.0015	18.99	135.21	0.83
152	39	5.17	24	1	24	0.96	0.0015	18.99	47.10	0.83
153	110	14.50	24	1	24	0.96	0.0015	18.99	132.17	0.83
154	39	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.86
155	61	7.58	24	1	24	0.96	0.0015	18.99	69.12	0.88
156	175	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.56
157	237	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.76
158	224	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.72
159	211	17.00	24	2	24	1.92	0.0015	18.99	309.92	0.68
160	43	8.50	24	1	24	0.96	0.0015	18.99	77.48	0.55
161	26	4.75	24	1	24	0.96	0.0015	18.99	43.30	0.60
162	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
163	26	4.75	24	1	24	0.96	0.0015	18.99	43.30	0.60

164	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
165	26	4.75	24	1	24	0.96	0.0015	18.99	43.30	0.60
166	34	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.45
167	12	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.48
168	7	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.28
169	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
170	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
171	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
172	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
173	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
174	17	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.36
175	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
176	116	8.25	24	2	24	1.92	0.0015	18.99	150.40	0.77
177	123	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.79
178	131	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.85
179	138	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.89
180	99	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.64
181	35	7.67	24	1	24	0.96	0.0015	18.99	69.88	0.50
182	23	4.42	24	1	24	0.96	0.0015	18.99	40.26	0.57
183	66	14.50	24	1	24	0.96	0.0015	18.99	132.17	0.50
184	25	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.52
185	66	14.25	24	1	24	0.96	0.0015	18.99	129.89	0.51
186	23	5.50	24	1	24	0.96	0.0015	18.99	50.13	0.46
187	68	15.42	24	1	24	0.96	0.0015	18.99	140.53	0.48
188	31	5.42	24	1	24	0.96	0.0015	18.99	49.37	0.63
189	42	9.50	24	1	24	0.96	0.0015	18.99	86.59	0.49
190	35	7.67	24	1	24	0.96	0.0015	18.99	69.88	0.50
191	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
192	66	14.67	24	1	24	0.96	0.0015	18.99	133.69	0.49
193	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
194	67	15.17	24	1	24	0.96	0.0015	18.99	138.25	0.48
195	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
196	32	6.83	24	1	24	0.96	0.0015	18.99	62.29	0.51

197	18	4.25	24	1	24	0.96	0.0015	18.99	38.74	0.46
198	115	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.74
199	123	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.79
200	131	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.85
201	138	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.89
202	102	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.66
203	7	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.28
204	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
205	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
206	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
207	15	4.75	24	1	24	0.96	0.0015	18.99	43.30	0.35
208	20	8.33	24	1	24	0.96	0.0015	18.99	75.96	0.26
209	16	5.42	24	1	24	0.96	0.0015	18.99	49.37	0.32
210	11	3.50	24	1	24	0.96	0.0015	18.99	31.90	0.34
211	10	3.50	24	1	24	0.96	0.0015	18.99	31.90	0.31
212	14	4.58	24	1	24	0.96	0.0015	18.99	41.78	0.34
213	30	10.00	24	1	24	0.96	0.0015	18.99	91.15	0.33
214	10	3.25	24	1	24	0.96	0.0015	18.99	29.62	0.34
215	16	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.35
216	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
217	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
218	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
219	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
220	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
221	7	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.28
222	123	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.79
223	131	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.85
224	138	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.89
225	100	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.65
226	41	9.17	24	1	24	0.96	0.0015	18.99	83.56	0.49
227	67	15.17	24	1	24	0.96	0.0015	18.99	138.25	0.48
228	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
229	66	14.75	24	1	24	0.96	0.0015	18.99	134.45	0.49

230	22	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.48
231	65	14.75	24	1	24	0.96	0.0015	18.99	134.45	0.48
232	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
233	36	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.51
234	36	7.75	24	1	24	0.96	0.0015	18.99	70.64	0.51
235	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
236	64	14.50	24	1	24	0.96	0.0015	18.99	132.17	0.48
237	23	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.50
238	66	14.75	24	1	24	0.96	0.0015	18.99	134.45	0.49
239	23	5.25	24	1	24	0.96	0.0015	18.99	47.85	0.48
240	44	10.08	24	1	24	0.96	0.0015	18.99	91.91	0.48
241	112	25.75	24	1	24	0.96	0.0015	18.99	234.72	0.48
242	123	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.79
243	131	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.85
244	138	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.89
245	102	17.00	24	1	24	0.96	0.0015	18.99	154.96	0.66
246	25	8.50	24	1	24	0.96	0.0015	18.99	77.48	0.32
247	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
248	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
249	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
250	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
251	15	5.00	24	1	24	0.96	0.0015	18.99	45.58	0.33
252	20	8.25	24	1	24	0.96	0.0015	18.99	75.20	0.27
253	7	2.75	24	1	24	0.96	0.0015	18.99	25.07	0.28

Airmen Dormitory - Building 854

Masonry Wall In-Plane Flexure Strengthening

1.0 DESIGN GOAL

Design the Tyfo FRP System to provide in-plane flexure capacity to existing unreinforced masonry block walls, as specified by Wallace Design Collective Structural Engineers.

2.0 GENERAL NOTES AND ASSUMPTIONS

1. The ultimate design strain of the Tyfo SCH-41 carbon composite system is 0.009 in/in. However, the maximum usable strain for flexural strengthening shall be taken as 0.005 in/in. per ASCE 41-17 section 10.3.3.1.
2. Assumed strength reduction factor (ϕ) can be taken to unity (1.0) for seismic design per ASCE-41.
3. Fyfe has not evaluated the existing structural capacity of the masonry block walls and therefore has not evaluated alternate failure modes that may occur prior to the FRP system reaching its allowable design strength. The FRP system is only designed to provide additional tension capacity to the masonry block walls acting as a vertically-oriented (in-plane flexure) tension member.
4. The lever arm of the FRP reinforcement (between extreme FRP tension and center of compression block) is taken as 80% of the distance between the centroid of the FRP reinforcement and the opposite end of the wall.
5. The depth of the compression block is taken as 20% of the total wall length.
6. The following calculation pertains to wall location ID 1. A summary of all wall strengthening calculations including anchor calculations is presented in the conclusion (section 7.0) and each calculation in the conclusion follows the procedure set forth in sections 3.0-6.0.
7. Location ID plans are attached to the back end of all Fyfe Calculations.

3.0 MATERIAL PROPERTIES OF THE TYFO SCH-41 CARBON COMPOSITE SYSTEM

Ultimate Properties:

$C_E := 0.95$	environmental reduction factor for interior environment (ACI 440.2R-17 Table 9.4)
$f_{fu} := 131 \text{ ksi}$	ultimate tensile stress
$f_f := C_E \cdot f_{fu} = 124.5 \text{ ksi}$	design ultimate tensile stress (eq. 9.4a)
$\epsilon_{fu} := 0.009 \frac{\text{in}}{\text{in}}$	ultimate tensile strain
$\epsilon_f := C_E \cdot \epsilon_{fu} = 0.0086 \frac{\text{in}}{\text{in}}$	design ultimate tensile strain (eq. 9.4b)
$E_f := \frac{f_f}{\epsilon_f} = 14555.6 \text{ ksi}$	ultimate modulus of elasticity

$$E_f := 12660 \text{ ksi}$$

design modulus of elasticity

$$t_f := 0.04 \cdot \text{in}$$

thickness per layer

4.0 EXISTING SECTION PROPERTIES

$$\phi := 1$$

strength reduction factor (taken to unity for seismic design per ASCE-41)

$$\beta_1 := 0.7$$

masonry compressive strength factor

$$l_w := 2.75 \text{ ft}$$

wall depth/length

$$h_w := 9 \text{ ft}$$

assumed wall height

5.0 FLEXURAL STRENGTHENING CALCULATIONS

$$V_u := 20 \text{ kip}$$

applied shear load

$$M_{req} := V_u \cdot h_w = 180 \text{ kip} \cdot \text{ft}$$

required flexural capacity

Moment Capacity from FRP

$$n := 4$$

number of layers of FRP

$$w_f := 12 \cdot \text{in}$$

width of fiber at wall end

$$A_f := n \cdot t_f \cdot w_f = 1.92 \text{ in}^2$$

effective composite area of FRP

$$\varepsilon_{fe} := 0.005 \frac{\text{in}}{\text{in}}$$

effective FRP strain

$$f_{fe} := E_f \cdot \varepsilon_{fe} = 63.3 \text{ ksi}$$

effective FRP stress

$$\phi M_f := \phi \cdot A_f \cdot f_{fe} \cdot \left(0.8 \cdot \left(l_w - \frac{w_f}{2} \right) \right) = 218.8 \text{ kip} \cdot \text{ft}$$

factored moment capacity provided by FRP

Moment Capacity from Axial Load

$$w_u := 3605 \text{ plf}$$

uniformly distributed load on first floor exterior wall

$$P_u := w_u \cdot l_w = 9.9 \text{ kip}$$

resultant point load from uniformly distributed load

$$\phi M_{Pu} := \phi \cdot P_u \cdot \left(\frac{l_w}{2} - \left(\frac{\beta_1 \cdot 0.2 \cdot l_w}{2} \right) \right) = 11.7 \text{ kip} \cdot \text{ft}$$

factored moment capacity from axial load

$$\phi M_n := \phi M_f + \phi M_{Pu} = 230.5 \text{ kip} \cdot \text{ft}$$

factored nominal moment capacity

$$DCR := \frac{M_{req}}{\phi M_n} = 0.78$$

6.0 TYFO SCH COMPOSITE ANCHOR CALCULATIONS

6.1 Anchor Rupture Calculation

$$T_{req} := \phi \cdot n \cdot t_f \cdot w_f \cdot f_{fe} = 121.5 \text{ kip}$$

tension force required on composite anchors

$$f_{fa} := 110 \cdot \text{ksi}$$

design ultimate tensile stress for anchors up to 7/8" diameter

$$d_a := \frac{7}{8} \cdot \text{in}$$

diameter of composite anchor

$$A_{fa} := \frac{\pi \cdot d_a^2}{4} = 0.60 \text{ in}^2$$

area of composite anchor

$$T_f := A_{fa} \cdot f_{fa} = 66.1 \text{ kip}$$

ultimate design tensile strength

$$n_{fa} := \frac{T_{req}}{T_f} = 1.837$$

req. number of anchors per 12" fiber width

$$n_{fa} := 2$$

number of anchors to be used

6.2 Anchor Development Calculation - Bonding to Fiber

$$T_{reqa} := \frac{T_{req}}{n_{fa}} = 60.8 \text{ kip}$$

tension to be developed between anchors and FRP for (1) anchor

$$\sigma := 500 \cdot \text{psi}$$

minimum bond strength of FRP to composite anchor

$$l_{sw} := 8 \cdot \text{in}$$

anchor splay width

$$l_s := 16 \cdot \text{in}$$

anchor splay length

$$n := 4$$

number of layers (anchor splayed between layers)

$$T_b := \left\{ \begin{array}{l} \text{if } n = 1 \\ \left\| \frac{1}{2} \cdot l_{sw} \cdot l_s \cdot \sigma \right\| \\ \text{if } n > 1 \\ \left\| l_{sw} \cdot l_s \cdot \sigma \right\| \end{array} \right\} = 64 \text{ kip}$$

tension to be developed through bond for one layer of FRP (bonded on one face)

tension to be developed through bond for two or more layers of FRP (bonded on both faces)

$$T_b = 64 \text{ kip}$$

tension to be developed through bond

$$DCR_A := \frac{T_{reqa}}{T_b} = 0.95$$

7.0 CONCLUSION

Install four layers of the Tyfo SCH-41 system, 12" wide strips applied to each wall end, with primary fibers oriented vertically to provide a moment capacity equal to 180 kip-ft.

At each strip end, install (2) - 7/8" diameter Tyfo SCH anchors spaced 6" on-center, with a minimum 8" splay width (2" splay overlap) and a minimum 16" splay length. Anchors embedded into the existing concrete footing/foundation shall be embedded a minimum 8" and anchors splaying onto the FRP strip located at the floor above shall be continuous through the existing concrete slab.

The table below summarizes all wall strengthening locations. The second table summarizes all anchor calculations for each wall location. Each calculation summarized in the following tables conforms to the calculation procedure set forth in sections 3.0-6.0 for Masonry Wall In-Plane Flexure Strengthening.

Wall Properties					Fiber Properties					Moment Capacity (k-ft.)		
Location ID #	M _{req} (kip-ft.)	w _u (plf)	P _u (kip)	Wall Length (ft.)	# layers	w _f (in.)	ε _{fe}	f _{fe} (ksi)	Moment Capacity (k-ft.) FROM FRP	Moment Capacity (k-ft.) FROM AXIAL LOAD	TOTAL φM _n (kip-ft)	DCR
1	180	3605	9.9	2.75	4	12	0.005	63.3	219	12	230	0.78
2	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
3	369	3605	18.0	5.00	2	24	0.005	63.3	389	39	428	0.86
4	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
5	369	3605	17.4	4.83	2	24	0.005	63.3	373	36	409	0.90
6	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
7	270	3605	9.3	2.58	5	15	0.005	63.3	298	10	308	0.88
8	1800	3605	61.0	16.92	2	24	0.005	63.3	1548	444	1991	0.90
9	2466	4435	74.7	16.83	2	36	0.005	63.3	2236	540	2777	0.89
10	2322	4435	75.8	17.08	2	36	0.005	63.3	2273	557	2829	0.82
11	2898	4435	75.0	16.92	3	36	0.005	63.3	3373	546	3918	0.74
12	2043	4435	75.4	17.00	2	24	0.005	63.3	1556	551	2107	0.97
13	270	4435	17.0	3.83	3	12	0.005	63.3	243	28	271	1.00
14	1008	4435	62.5	14.08	2	12	0.005	63.3	660	378	1039	0.97
15	369	4435	23.3	5.25	2	24	0.005	63.3	413	53	466	0.79
16	1062	4435	65.8	14.83	2	12	0.005	63.3	697	420	1116	0.95
17	396	4435	25.1	5.67	2	24	0.005	63.3	454	61	515	0.77
18	1062	4435	65.8	14.83	2	12	0.005	63.3	697	420	1116	0.95
19	378	4435	22.9	5.17	2	24	0.005	63.3	405	51	456	0.83
20	567	4435	34.4	7.75	2	24	0.005	63.3	656	115	771	0.74
21	567	4435	33.6	7.58	2	24	0.005	63.3	640	110	750	0.76
22	378	4435	22.5	5.08	2	24	0.005	63.3	397	49	446	0.85
23	1053	4435	65.0	14.67	2	12	0.005	63.3	689	410	1099	0.96
24	396	4435	25.1	5.67	2	24	0.005	63.3	454	61	515	0.77
25	1053	4435	65.8	14.83	2	12	0.005	63.3	697	420	1116	0.94
26	378	4435	23.3	5.25	2	24	0.005	63.3	413	53	466	0.81
27	513	4435	30.3	6.83	2	24	0.005	63.3	567	89	656	0.78
28	1233	4435	56.2	12.67	2	24	0.005	63.3	1134	306	1440	0.86
29	1836	3605	69.1	19.17	2	24	0.005	63.3	1766	569	2336	0.79
30	2466	4435	75.8	17.08	2	36	0.005	63.3	2273	557	2829	0.87
31	2322	4435	75.4	17.00	2	36	0.005	63.3	2261	551	2812	0.83
32	2898	4435	75.4	17.00	3	36	0.005	63.3	3391	551	3942	0.74
33	2709	4435	56.9	12.83	3	36	0.005	63.3	2479	314	2793	0.97
34	297	3605	14.4	4.00	2	24	0.005	63.3	292	25	316	0.94
35	396	3605	18.9	5.25	2	24	0.005	63.3	413	43	456	0.87
36	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
37	351	3605	16.8	4.67	2	24	0.005	63.3	357	34	390	0.90
38	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
39	369	3605	18.0	5.00	2	24	0.005	63.3	389	39	428	0.86
40	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
41	171	3605	10.2	2.83	3	12	0.005	63.3	170	12	183	0.94
42	576	3605	24.6	6.83	2	24	0.005	63.3	567	72	640	0.90
43	243	3605	11.7	3.25	4	12	0.005	63.3	267	16	284	0.86
44	378	3605	18.6	5.17	2	24	0.005	63.3	405	41	447	0.85
45	486	3605	34.2	9.50	2	12	0.005	63.3	438	140	577	0.84
46	369	3605	18.3	5.08	2	24	0.005	63.3	397	40	437	0.84
47	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
48	369	3605	18.0	5.00	2	24	0.005	63.3	389	39	428	0.86
49	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
50	171	3605	10.2	2.83	3	12	0.005	63.3	170	12	183	0.94
51	2187	4435	75.4	17.00	2	36	0.005	63.3	2261	551	2812	0.78
52	2331	4435	75.4	17.00	2	36	0.005	63.3	2261	551	2812	0.83
53	2475	4435	75.4	17.00	2	36	0.005	63.3	2261	551	2812	0.88
54	1809	4435	75.4	17.00	2	24	0.005	63.3	1556	551	2107	0.86
55	576	4435	34.4	7.75	2	24	0.005	63.3	656	115	771	0.75
56	369	4435	48.4	10.92	2	12	0.005	63.3	506	227	734	0.50

57	1053	4435	65.8	14.83	2	12	0.005	63.3	697	420	1116	0.94
58	351	4435	21.4	4.83	2	24	0.005	63.3	373	45	417	0.84
59	1062	4435	64.7	14.58	2	12	0.005	63.3	685	406	1090	0.97
60	369	4435	23.3	5.25	2	24	0.005	63.3	413	53	466	0.79
61	3033	4435	147.1	33.17	2	12	0.005	63.3	1588	2098	3686	0.82
62	1431	4435	88.3	19.92	2	12	0.005	63.3	944	756	1700	0.84
63	711	4435	44.0	9.92	2	24	0.005	63.3	867	188	1054	0.67
64	369	4435	22.9	5.17	2	24	0.005	63.3	405	51	456	0.81
65	1053	4435	66.5	15.00	2	12	0.005	63.3	705	429	1134	0.93
66	369	4435	22.9	5.17	2	24	0.005	63.3	405	51	456	0.81
67	1035	4435	64.3	14.50	2	12	0.005	63.3	681	401	1082	0.96
68	369	4435	35.5	8.00	2	12	0.005	63.3	365	122	487	0.76
69	576	4435	34.0	7.67	2	24	0.005	63.3	648	112	760	0.76
70	1845	3605	61.0	16.92	2	24	0.005	63.3	1548	444	1991	0.93
71	2475	4435	75.0	16.92	2	36	0.005	63.3	2248	546	2794	0.89
72	2331	4435	76.1	17.17	2	36	0.005	63.3	2285	562	2847	0.82
73	2187	4435	75.8	17.08	2	36	0.005	63.3	2273	557	2829	0.77
74	603	3605	29.1	8.08	2	24	0.005	63.3	689	101	790	0.76
75	369	3605	18.3	5.08	2	24	0.005	63.3	397	40	437	0.84
76	441	3605	27.6	7.67	2	24	0.005	63.3	648	91	739	0.60
77	369	3605	18.0	5.00	2	24	0.005	63.3	389	39	428	0.86
78	486	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.60
79	324	3605	18.0	5.00	2	24	0.005	63.3	389	39	428	0.76
80	531	3605	29.7	8.25	2	24	0.005	63.3	705	106	810	0.66
81	135	3605	9.3	2.58	3	12	0.005	63.3	152	10	162	0.83
82	108	2320	6.2	2.67	2	12	0.005	63.3	105	7	112	0.96
83	315	2320	19.3	8.33	2	12	0.005	63.3	381	69	450	0.70
84	234	2320	11.6	5.00	2	12	0.005	63.3	219	25	244	0.96
85	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
86	234	2320	11.4	4.92	2	12	0.005	63.3	215	24	239	0.98
87	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
88	252	2320	12.4	5.33	2	12	0.005	63.3	235	28	263	0.96
89	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
90	1530	2320	39.2	16.92	2	24	0.005	63.3	1548	285	1833	0.83
91	2133	2790	47.7	17.08	2	36	0.005	63.3	2273	350	2623	0.81
92	2016	2790	47.7	17.08	2	36	0.005	63.3	2273	350	2623	0.77
93	1899	2790	47.7	17.08	2	24	0.005	63.3	1564	350	1914	0.99
94	1782	2790	47.4	17.00	2	24	0.005	63.3	1556	347	1902	0.94
95	648	2790	26.7	9.58	2	24	0.005	63.3	835	110	945	0.69
96	360	2790	14.6	5.25	2	24	0.005	63.3	413	33	446	0.81
97	1044	2790	42.5	15.25	2	24	0.005	63.3	1386	279	1665	0.63
98	360	2790	14.6	5.25	2	24	0.005	63.3	413	33	446	0.81
99	1008	2790	41.4	14.83	2	24	0.005	63.3	1345	264	1609	0.63
100	378	2790	14.9	5.33	2	24	0.005	63.3	421	34	455	0.83
101	1008	2790	41.9	15.00	2	24	0.005	63.3	1361	270	1631	0.62
102	360	2790	14.2	5.08	2	24	0.005	63.3	397	31	428	0.84
103	540	2790	21.4	7.67	2	24	0.005	63.3	648	71	719	0.75
104	540	2790	21.6	7.75	2	24	0.005	63.3	656	72	728	0.74
105	360	2790	14.4	5.17	2	24	0.005	63.3	405	32	437	0.82
106	1008	2790	41.9	15.00	2	24	0.005	63.3	1361	270	1631	0.62
107	360	2790	14.4	5.17	2	24	0.005	63.3	405	32	437	0.82
108	1035	2790	42.3	15.17	2	24	0.005	63.3	1377	276	1653	0.63
109	360	2790	14.2	5.08	2	24	0.005	63.3	397	31	428	0.84
110	495	2790	18.8	6.75	2	24	0.005	63.3	559	55	614	0.81
111	369	2790	12.8	4.58	2	24	0.005	63.3	348	25	374	0.99
112	1683	2790	47.4	17.00	2	24	0.005	63.3	1556	347	1902	0.88
113	1899	2790	47.4	17.00	2	24	0.005	63.3	1556	347	1902	1.00
114	2016	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.77
115	2133	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.82
116	1584	2320	39.4	17.00	2	24	0.005	63.3	1556	288	1844	0.86

117	108	2320	6.4	2.75	2	12	0.005	63.3	109	8	117	0.92
118	315	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.71
119	234	2320	11.6	5.00	2	12	0.005	63.3	219	25	244	0.96
120	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
121	225	2320	10.6	4.58	2	24	0.005	63.3	348	21	369	0.61
122	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
123	252	2320	12.0	5.17	2	12	0.005	63.3	227	27	253	0.99
124	162	2320	8.1	3.50	3	12	0.005	63.3	219	12	231	0.70
125	153	2320	7.5	3.25	3	12	0.005	63.3	201	11	211	0.72
126	216	2320	10.8	4.67	2	12	0.005	63.3	203	22	224	0.96
127	468	2320	23.0	9.92	2	12	0.005	63.3	458	98	556	0.84
128	162	2320	7.3	3.17	3	12	0.005	63.3	194	10	204	0.79
129	234	2320	11.6	5.00	2	12	0.005	63.3	219	25	244	0.96
130	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
131	234	2320	11.6	5.00	2	12	0.005	63.3	219	25	244	0.96
132	306	2320	18.9	8.17	2	12	0.005	63.3	373	67	439	0.70
133	234	2320	11.6	5.00	2	12	0.005	63.3	219	25	244	0.96
134	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
135	108	2320	6.4	2.75	2	12	0.005	63.3	109	8	117	0.92
136	1548	2320	39.4	17.00	2	24	0.005	63.3	1556	288	1844	0.84
137	2133	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.82
138	2016	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.77
139	1899	2790	47.4	17.00	2	24	0.005	63.3	1556	347	1902	1.00
140	630	2790	27.0	9.67	2	24	0.005	63.3	843	112	955	0.66
141	1035	2790	41.2	14.75	2	24	0.005	63.3	1337	261	1598	0.65
142	351	2790	14.2	5.08	2	24	0.005	63.3	397	31	428	0.82
143	1008	2790	41.4	14.83	2	24	0.005	63.3	1345	264	1609	0.63
144	333	2790	13.3	4.75	2	24	0.005	63.3	365	27	392	0.85
145	1008	2790	41.2	14.75	2	24	0.005	63.3	1337	261	1598	0.63
146	351	2790	14.0	5.00	2	24	0.005	63.3	389	30	419	0.84
147	549	2790	21.6	7.75	2	24	0.005	63.3	656	72	728	0.75
148	1746	2790	71.6	25.67	2	12	0.005	63.3	1223	790	2014	0.87
149	684	2790	27.2	9.75	2	24	0.005	63.3	851	114	965	0.71
150	351	2790	14.0	5.00	2	24	0.005	63.3	389	30	419	0.84
151	1008	2790	41.4	14.83	2	24	0.005	63.3	1345	264	1609	0.63
152	351	2790	14.4	5.17	2	24	0.005	63.3	405	32	437	0.80
153	990	2790	40.5	14.50	2	24	0.005	63.3	1313	252	1565	0.63
154	351	2790	14.0	5.00	2	24	0.005	63.3	389	30	419	0.84
155	549	2790	21.2	7.58	2	24	0.005	63.3	640	69	709	0.77
156	1575	2320	39.4	17.00	2	24	0.005	63.3	1556	288	1844	0.85
157	2133	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.82
158	2016	2790	47.4	17.00	2	36	0.005	63.3	2261	347	2607	0.77
159	1899	2790	47.4	17.00	2	24	0.005	63.3	1556	347	1902	1.00
160	387	2320	19.7	8.50	2	12	0.005	63.3	389	72	461	0.84
161	234	2320	11.0	4.75	2	24	0.005	63.3	365	23	387	0.60
162	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
163	234	2320	11.0	4.75	2	24	0.005	63.3	365	23	387	0.60
164	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
165	234	2320	11.0	4.75	2	24	0.005	63.3	365	23	387	0.60
166	306	2320	19.1	8.25	2	12	0.005	63.3	377	68	445	0.69
167	108	2320	6.4	2.75	2	12	0.005	63.3	109	8	117	0.92
168	63	405	1.1	2.75	2	12	0.005	63.3	109	1	111	0.57
169	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
170	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
171	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
172	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
173	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
174	153	405	2.1	5.25	2	12	0.005	63.3	231	5	236	0.65
175	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
176	1044	515	4.2	8.25	3	24	0.005	63.3	1057	15	1072	0.97

177	1107	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.68
178	1179	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.73
179	1242	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.77
180	891	405	6.9	17.00	2	24	0.005	63.3	1556	50	1606	0.55
181	315	515	3.9	7.67	2	12	0.005	63.3	348	13	361	0.87
182	207	515	2.3	4.42	2	24	0.005	63.3	332	4	337	0.62
183	594	515	7.5	14.50	2	12	0.005	63.3	681	47	727	0.82
184	225	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.95
185	594	515	7.3	14.25	2	12	0.005	63.3	668	45	713	0.83
186	207	515	2.8	5.50	2	12	0.005	63.3	243	7	250	0.83
187	612	515	7.9	15.42	2	12	0.005	63.3	725	53	778	0.79
188	279	515	2.8	5.42	2	24	0.005	63.3	429	6	436	0.64
189	378	515	4.9	9.50	2	12	0.005	63.3	438	20	458	0.83
190	315	515	3.9	7.67	2	12	0.005	63.3	348	13	361	0.87
191	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
192	594	515	7.6	14.67	2	12	0.005	63.3	689	48	736	0.81
193	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
194	603	515	7.8	15.17	2	12	0.005	63.3	713	51	764	0.79
195	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
196	288	515	3.5	6.83	2	12	0.005	63.3	308	10	318	0.91
197	162	515	2.2	4.25	2	12	0.005	63.3	182	4	186	0.87
198	1035	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.64
199	1107	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.68
200	1179	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.73
201	1242	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.77
202	918	405	6.9	17.00	2	24	0.005	63.3	1556	50	1606	0.57
203	63	405	1.1	2.75	2	12	0.005	63.3	109	1	111	0.57
204	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
205	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
206	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
207	135	405	1.9	4.75	2	12	0.005	63.3	207	4	211	0.64
208	180	405	3.4	8.33	2	12	0.005	63.3	381	12	393	0.46
209	144	405	2.2	5.42	2	12	0.005	63.3	239	5	244	0.59
210	99	405	1.4	3.50	2	12	0.005	63.3	146	2	148	0.67
211	90	405	1.4	3.50	2	12	0.005	63.3	146	2	148	0.61
212	126	405	1.9	4.58	2	12	0.005	63.3	199	4	202	0.62
213	270	405	4.1	10.00	2	12	0.005	63.3	462	17	479	0.56
214	90	405	1.3	3.25	2	12	0.005	63.3	134	2	136	0.66
215	144	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.65
216	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
217	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
218	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
219	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
220	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
221	63	405	1.1	2.75	2	12	0.005	63.3	109	1	111	0.57
222	1107	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.68
223	1179	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.73
224	1242	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.77
225	900	405	6.9	17.00	2	24	0.005	63.3	1556	50	1606	0.56
226	369	515	4.7	9.17	2	12	0.005	63.3	421	19	440	0.84
227	603	515	7.8	15.17	2	12	0.005	63.3	713	51	764	0.79
228	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
229	594	515	7.6	14.75	2	12	0.005	63.3	693	48	741	0.80
230	198	515	2.6	5.00	2	12	0.005	63.3	219	6	224	0.88
231	585	515	7.6	14.75	2	12	0.005	63.3	693	48	741	0.79
232	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
233	324	515	4.0	7.75	2	12	0.005	63.3	352	13	366	0.89
234	324	515	4.0	7.75	2	12	0.005	63.3	352	13	366	0.89
235	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
236	576	515	7.5	14.50	2	12	0.005	63.3	681	47	727	0.79

237	207	515	2.6	5.00	2	12	0.005	63.3	219	6	224	0.92
238	594	515	7.6	14.75	2	12	0.005	63.3	693	48	741	0.80
239	207	515	2.7	5.25	2	12	0.005	63.3	231	6	237	0.87
240	396	515	5.2	10.08	2	12	0.005	63.3	466	23	488	0.81
241	1008	515	13.3	25.75	2	12	0.005	63.3	1228	147	1374	0.73
242	1107	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.68
243	1179	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.73
244	1242	515	8.8	17.00	2	24	0.005	63.3	1556	64	1620	0.77
245	918	405	6.9	17.00	2	24	0.005	63.3	1556	50	1606	0.57
246	225	405	3.4	8.50	2	12	0.005	63.3	389	13	401	0.56
247	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
248	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
249	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
250	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
251	135	405	2.0	5.00	2	12	0.005	63.3	219	4	223	0.61
252	180	405	3.3	8.25	2	12	0.005	63.3	377	12	389	0.46
253	63	405	1.1	2.75	2	12	0.005	63.3	109	1	111	0.57

Anchor Calculations							Bond					
Location ID #	T _{req} (kips)	d _a (in)	A _{fa} (in ²)	T _f (kips)	n _{fa}	n _{ra}	T _{reqa} (kips)	σ (ksi)	l _{sw} (in)	l _s (in)	T _b (kips)	DCR _A
1	121.5	7/8	0.60	66.1	1.84	2.00	60.8	0.50	8	16	64.0	0.95
2	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
3	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
4	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
5	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
6	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
7	189.9	7/8	0.60	66.1	2.87	3.00	68.3	0.50	8	16	64.0	0.99
8	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
9	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
10	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
11	273.5	7/8	0.60	66.1	4.13	5.00	54.7	0.50	8	16	64.0	0.85
12	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
13	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
14	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
15	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
16	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
17	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
18	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
19	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
20	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
21	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
22	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
23	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
24	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
25	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
26	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63

27	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
28	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
29	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
30	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
31	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
32	273.5	7/8	0.60	66.1	4.13	5.00	54.7	0.50	8	16	64.0	0.85
33	273.5	7/8	0.60	66.1	4.13	5.00	54.7	0.50	8	16	64.0	0.85
34	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
35	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
36	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
37	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
38	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
39	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
40	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
41	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
42	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
43	121.5	7/8	0.60	66.1	1.84	2.00	60.8	0.50	8	16	64.0	0.95
44	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
45	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
46	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
47	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
48	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
49	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
50	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
51	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
52	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
53	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
54	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
55	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
56	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63

57	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
58	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
59	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
60	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
61	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
62	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
63	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
64	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
65	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
66	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
67	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
68	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
69	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
70	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
71	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
72	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
73	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
74	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
75	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
76	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
77	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
78	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
79	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
80	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
81	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71

82	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
83	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
84	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
85	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
86	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63

87	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
88	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
89	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
90	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
91	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
92	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
93	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
94	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
95	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
96	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
97	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
98	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
99	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
100	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
101	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
102	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
103	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
104	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
105	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
106	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
107	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
108	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
109	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
110	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
111	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
112	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
113	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
114	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
115	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
116	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63

117	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
118	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
119	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
120	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
121	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
122	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
123	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
124	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
125	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
126	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
127	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
128	91.2	7/8	0.60	66.1	1.38	2.00	45.6	0.50	8	16	64.0	0.71
129	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
130	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
131	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
132	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
133	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
134	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
135	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
136	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
137	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
138	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
139	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
140	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
141	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
142	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
143	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
144	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
145	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
146	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63

147	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
148	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
149	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
150	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
151	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
152	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
153	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
154	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
155	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
156	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
157	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
158	182.3	5/8	0.31	33.7	5.40	6.00	30.4	0.50	8	12	48.0	0.63
159	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
160	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
161	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
162	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
163	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
164	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
165	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
166	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
167	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
168	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
169	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
170	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63

171	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
172	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
173	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
174	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
175	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
176	182.3	7/8	0.60	66.1	2.76	3.00	60.8	0.50	8	16	64.0	0.95
177	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
178	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
179	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
180	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
181	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
182	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
183	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
184	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
185	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
186	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
187	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
188	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
189	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
190	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
191	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
192	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
193	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
194	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
195	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
196	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
197	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
198	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
199	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
200	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
201	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
202	121.5	5/8	0.31	33.7	3.60	4.00	30.4	0.50	8	12	48.0	0.63
203	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
204	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
205	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63
206	60.8	5/8	0.31	33.7	1.80	2.00	30.4	0.50	8	12	48.0	0.63

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Airmen Dormitory - Building 854

Concrete Chord Strengthening Calculations

1.0 DESIGN GOAL

Design the Tyfo FRP System to resist the required chord tension force, as specified on the structural drawings provided by Wallace Design Collective Structural Engineers.

2.0 GENERAL NOTES AND ASSUMPTIONS

1. Assumed a maximum design strain in the FRP system as the minimum of 0.004 or flexural de-bonding strain per ACI 440.2R-17, equation 10.1.1.
2. Assumed an existing concrete slab strength of 4000psi.

3.0 MATERIAL PROPERTIES OF THE TYFO SCH-41 CARBON COMPOSITE SYSTEM

Ultimate Properties:

$C_E := 0.95$	environmental reduction factor for interior environment (ACI 440.2R-17 Table 9.4)
$f_{fu} := 131 \cdot \text{ksi}$	ultimate tensile stress
$f_f := C_E \cdot f_{fu} = 124.5 \text{ ksi}$	design ultimate tensile stress (eq. 9.4a)
$\epsilon_{fu} := 0.009 \frac{\text{in}}{\text{in}}$	ultimate tensile strain
$\epsilon_f := C_E \cdot \epsilon_{fu} = 0.0086 \frac{\text{in}}{\text{in}}$	design ultimate tensile strain (eq. 9.4b)
$E_f := \frac{f_f}{\epsilon_f} = 14555.6 \text{ ksi}$	ultimate modulus of elasticity
$E_f := 12660 \text{ ksi}$	design modulus of elasticity
$t_f := 0.04 \cdot \text{in}$	thickness per layer

4.0 EXISTING SECTION PROPERTIES

$$f'_c := 4000 \text{ psi}$$

assumed existing concrete compressive strength

$$\psi_f := 0.85$$

FRP reduction factor

5.0 TENSION EQUIVALENCE CALCULATIONS

First Floor

$$T_{req} := 62 \text{ kip}$$

required chord tension force

$$w_f := 24 \text{ in}$$

width of FRP

$$n := 2$$

number of layers

$$\varepsilon_{fd} := 0.083 \cdot \sqrt{\frac{f'_c}{n \cdot t_f \cdot \frac{1}{\text{in}} \cdot E_f}} = 0.0052$$

de-bonding FRP strain

$$\varepsilon_{fe} := \min(0.004, \varepsilon_{fd}) = 0.004$$

conservative effective FRP strain

$$f_{fe} := E_f \cdot \varepsilon_{fe} = 50.6 \text{ ksi}$$

effective stress of FRP

$$T_f := \psi_f \cdot n \cdot t_f \cdot w_f \cdot f_{fe} = 82.6 \text{ kip}$$

tension capacity provided by FRP

$$DCR := \frac{T_{req}}{T_f} = 0.75$$

Second Floor

$$T_{req} := 45.6 \text{ kip}$$

required tension force

$$w_f := 24 \text{ in}$$

width of FRP

$$n := 2$$

number of layers

$$\varepsilon_{fd} := 0.083 \cdot \sqrt{\frac{f'_c}{n \cdot t_f \cdot \frac{1}{\text{in}} \cdot E_f}} = 0.0052$$

de-bonding FRP strain

$$\varepsilon_{fe} := \min(0.004, \varepsilon_{fd}) = 0.004$$

conservative effective FRP strain

$$f_{fe} := E_f \cdot \varepsilon_{fe} = 50.6 \text{ ksi}$$

effective stress of FRP

$$T_f := \psi_f \cdot n \cdot t_f \cdot w_f \cdot f_{fe} = 82.6 \text{ kip}$$

tension capacity provided by FRP

$$DCR := \frac{T_{req}}{T_f} = 0.55$$

Third Floor

$$T_{req} := 26.5 \text{ kip}$$

total required tension force

$$w_f := 24 \text{ in}$$

width of FRP

$$n := 1$$

number of layers to be used

$$\varepsilon_{fd} := 0.083 \cdot \sqrt{\frac{f_c}{n \cdot t_f \cdot \frac{1}{\text{in}} \cdot E_f}} = 0.0074$$

de-bonding FRP strain

$$\varepsilon_{fe} := \min(0.004, \varepsilon_{fd}) = 0.004$$

conservative effective FRP strain

$$f_{fe} := E_f \cdot \varepsilon_{fe} = 50.6 \text{ ksi}$$

effective stress of FRP

$$T_f := \psi_f \cdot n \cdot t_f \cdot w_f \cdot f_{fe} = 41.3 \text{ kip}$$

tension capacity provided by FRP

$$DCR := \frac{T_{req}}{T_f} = 0.64$$

6.0 CONCLUSION

First Floor:

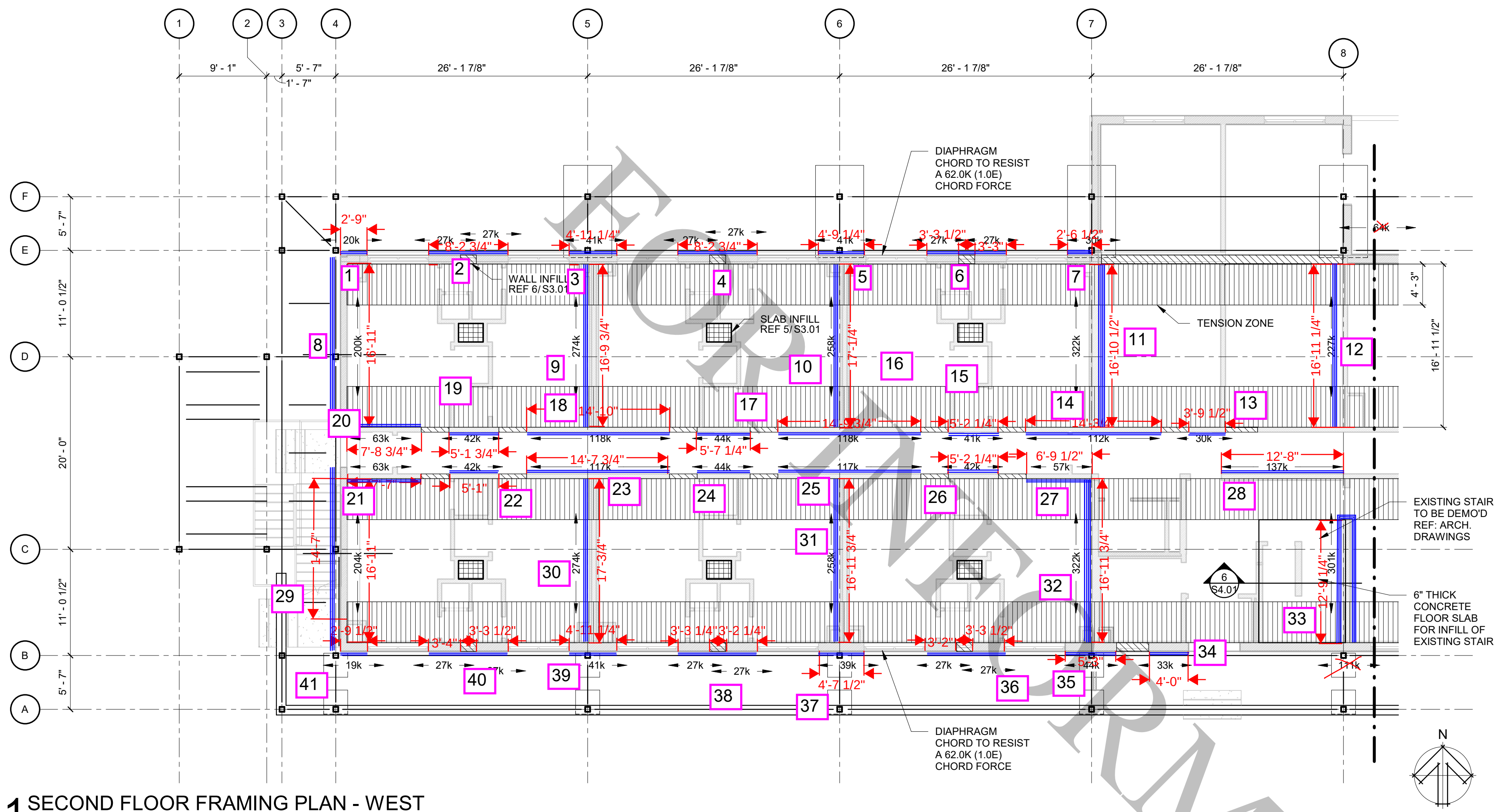
Install (2) layers of the Tyfo SCH-41 system, 24" wide strips, with primary fibers oriented in the E-W direction as indicated on plan, continuously applied to the topside of the existing concrete slab, in all locations indicated on the structural drawings provided by Wallace Design Collective Structural Engineers.

Second Floor:

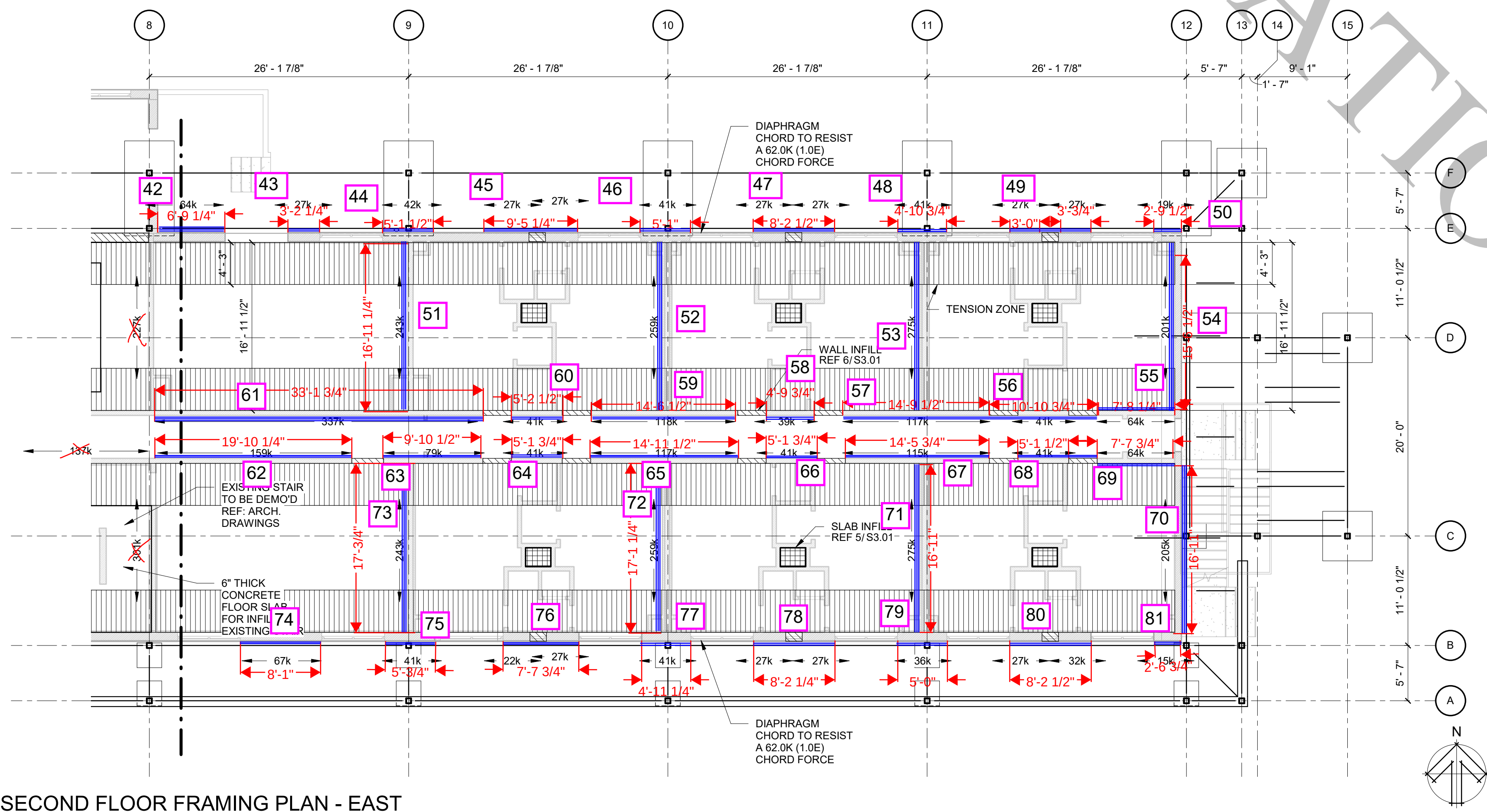
Install (2) layers of the Tyfo SCH-41 system, 24" wide strips, with primary fibers oriented in the E-W direction as indicated on plan, continuously applied to the topside of the existing concrete slab, in all locations indicated on the structural drawings provided by Wallace Design Collective Structural Engineers.

Third Floor:

Install (1) layer of the Tyfo SCH-41 system, 24" wide strips, with primary fibers oriented in the E-W direction as indicated on plan, continuously applied to the topside of the existing concrete slab, in all locations indicated on the structural drawings provided by Wallace Design Collective Structural Engineers.



1 SECOND FLOOR FRAMING PLAN - WEST
1/8" = 1'-0"



2 SECOND FLOOR FRAMING PLAN - EAST
1/8" = 1'-0"

- PLAN NOTES:**
1. TOP OF FINISHED FLOOR ELEVATION = 111'-6 1/2" U.N.O.
 2. CONTRACTOR SHALL NOT CUT, CORE, OR BORE HOLES IN EXISTING MEMBERS, INCLUDING MASONRY WALLS, HOLLOW CORE PLANKS, AND DECK, UNLESS APPROVED BY E.O.R.
 3. ALL MEMBERS SHOWN ON THIS PLAN ARE EXISTING, U.N.O.
 4. CONDITIONS, DIMENSIONS, AND MEMBER LOCATIONS SHOWN ON THIS PLAN HAVE BEEN TAKEN FROM EXISTING DRAWINGS AND SITE OBSERVATIONS. DETAILS HAVE BEEN DEVELOPED BASED ON THE BEST AVAILABLE INFORMATION. CONTRACTOR SHALL FIELD VERIFY ALL CONDITIONS AND DIMENSIONS SHOWN, AND, IF THE AS-BUILT CONDITION IS DIFFERENT THAN THAT REPRESENTED IN THESE DOCUMENTS, SHALL NOTIFY THE ARCHITECT AND ENGINEER PRIOR TO PROCEEDING WITH THE WORK.
 5. FIELD VERIFY T.O. FINISH FLOOR ELEVATIONS, OPENING SIZES AND EXISTING REINFORCEMENT PRIOR TO FABRICATION AND CONSTRUCTION.
 6. EXISTING JAMB REINFORCEMENT SHALL BE FIELD VERIFIED. IF EXISTING CONDITIONS DIFFER FROM DETAILS ON SHEET S.501, CONTACT E.O.R.

PLAN REFERENCE NOTES:

- A. VERIFY OPENING SIZE WITH MEP AND ARCH.
- B. COORDINATE LOCATION WITH MEP/ARCH. OPENING LOCATION CAN MOVE ALONG EXTERIOR WALL TO A LIMITED EXTENT. VERIFY FINAL OPENING LOCATION IS ACCEPTABLE TO ALL PARTIES.
- C. FRP SUBCONTRACTOR SHALL PROVIDE CALCS AND DRAWINGS WET STAMPED BY REGISTERED PROFESSIONAL ENGINEER WHO IS LEGALLY AUTHORIZED TO PRACTICE IN THE STATE OF ARKANSAS AND WHO IS EXPERIENCED IN FRP DESIGN.
- D. THE ENGINEER OF RECORD WILL REVIEW THE CALCS AND SHOP DRAWINGS BUT THE REVIEW IS LIMITED TO CHECKING FOR GENERAL CONFORMANCE WITH THE DESIGN DRAWINGS.

LEGEND:

1. OPENING IN MASONRY WALL PER ELEVATION PER SHEETS S1.02, S1.03, AND S1.04.
- ###k--- SEISMIC IN-PLANE SHEARWALL LOAD (LRFD)



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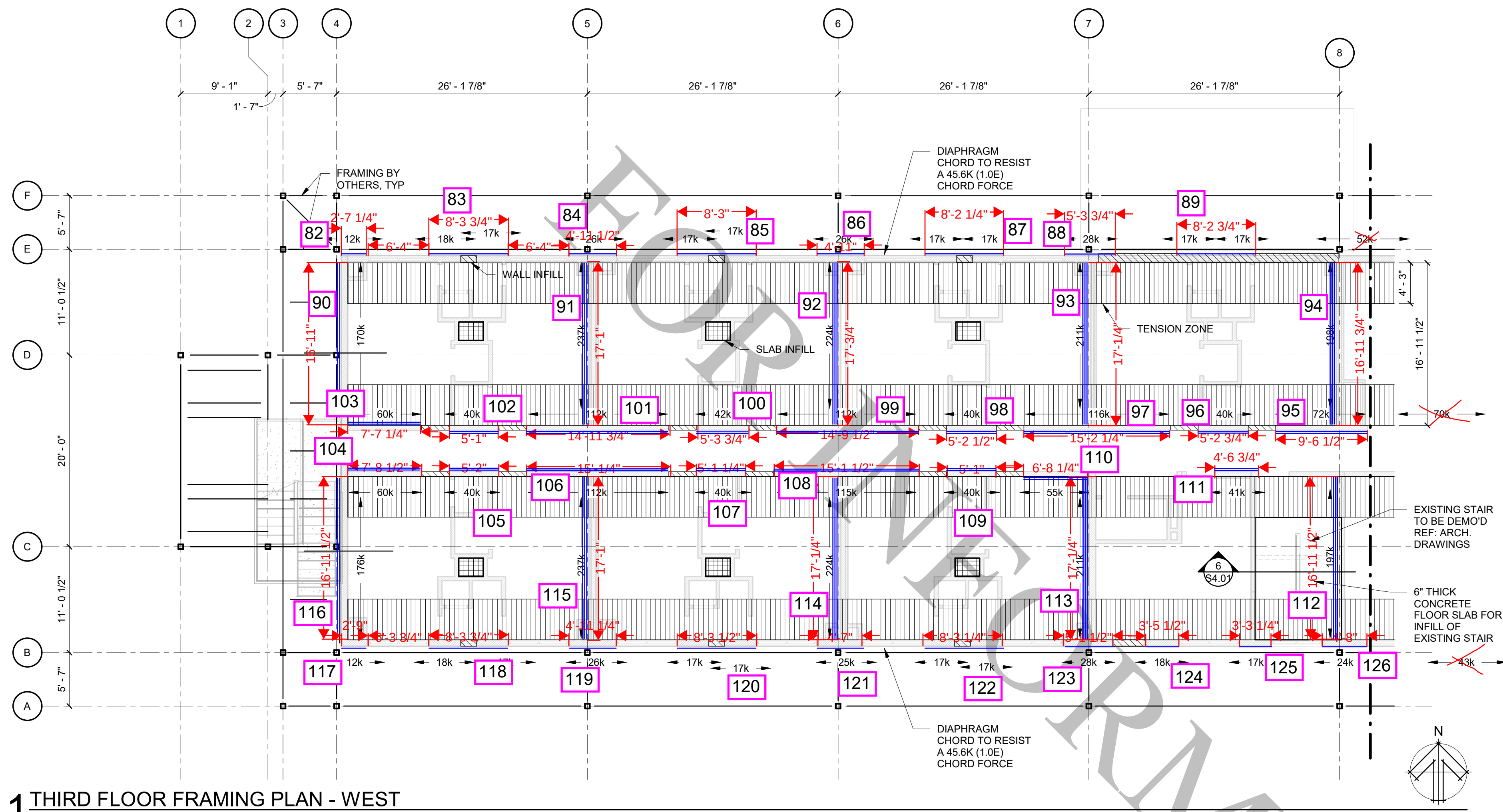
No.	Revision/Issue	Date	BY	APP'D

PROJECT TITLE
**REPAIR (SUS) AIRMEN
DORMITORY BLDG 854**

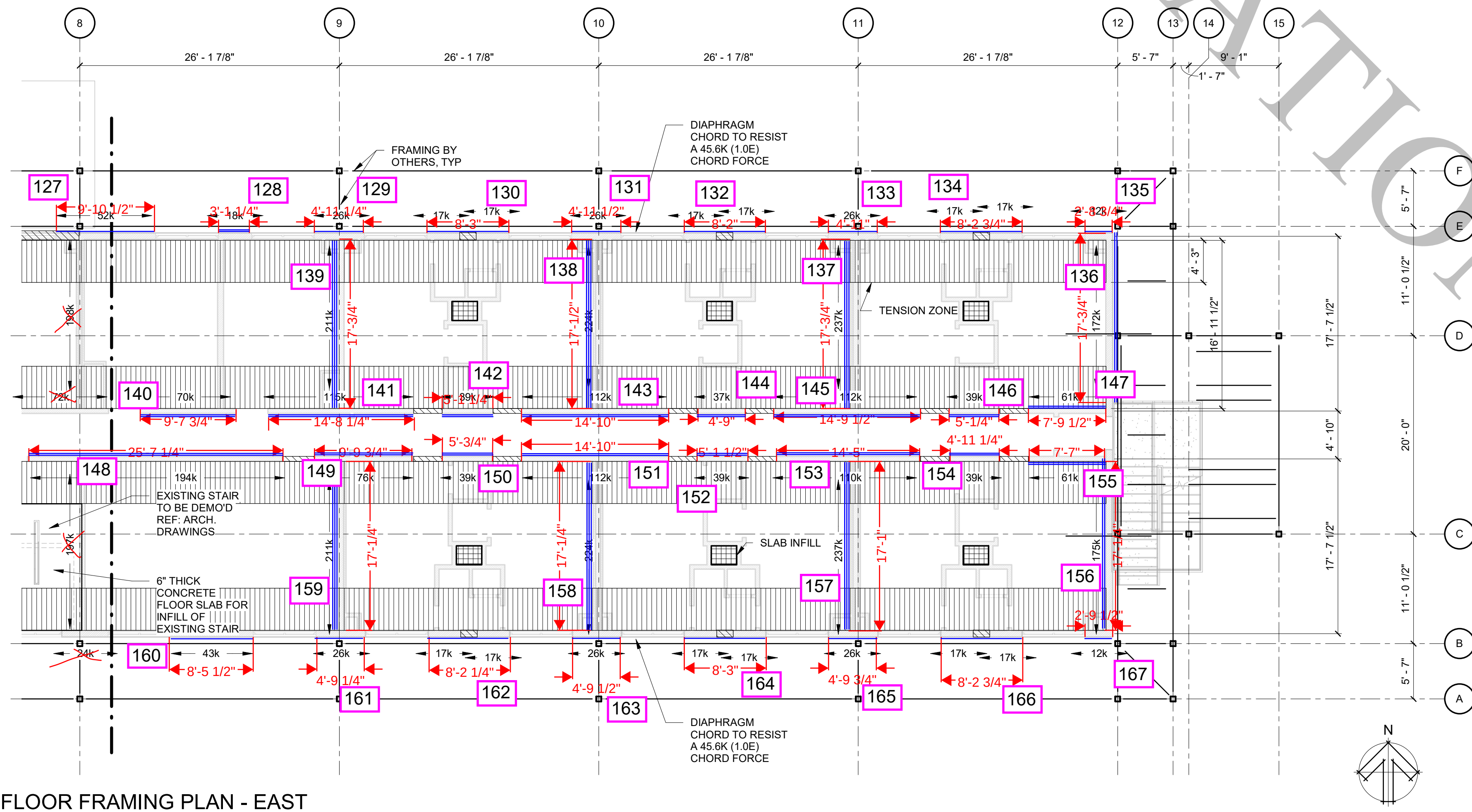
SHEET TITLE
**SECOND FLOOR FRAMING
PLAN**

DRAWN BY AJG	SLAB DESIGNER AJG
TECH. REVIEWER JMG	PROJECT NUMBER NKAK 21-1034
DESIGNED BY AJG	SHEET S1.02
DATE 16 NOV. 2023	
SCALE AS NOTED	

95% PRE-FINAL DESIGN SUBMITTAL



1 THIRD FLOOR FRAMING PLAN - WEST
1/8" = 1'-0"



2 THIRD FLOOR FRAMING PLAN - EAST
1/8" = 1'-0"

- PLAN NOTES:**
1. TOP OF FINISHED FLOOR ELEVATION = 111'-8 1/2" U.N.O.
 2. CONTRACTOR SHALL NOT CUT, CORE, OR BORE HOLES IN EXISTING MEMBERS, INCLUDING MASONRY WALLS, HOLLOW CORE PLANKS, AND DECK, UNLESS APPROVED BY E.O.R.
 3. ALL MEMBERS SHOWN ON THIS PLAN ARE EXISTING, U.N.O.
 4. CONDITIONS, DIMENSIONS, AND MEMBER LOCATIONS SHOWN ON THIS PLAN HAVE BEEN TAKEN FROM EXISTING DRAWINGS AND SITE OBSERVATIONS. DETAILS HAVE BEEN DEVELOPED BASED ON THE BEST AVAILABLE INFORMATION. CONTRACTOR SHALL FIELD VERIFY ALL CONDITIONS AND DIMENSIONS SHOWN, AND, IF THE AS-BUILT CONDITION IS DIFFERENT THAN THAT REPRESENTED IN THESE DOCUMENTS, SHALL NOTIFY THE ARCHITECT AND ENGINEER PRIOR TO PROCEEDING WITH THE WORK.
 5. FIELD VERIFY T.O. FINISH FLOOR ELEVATIONS, OPENING SIZES AND EXISTING REINFORCEMENT PRIOR TO FABRICATION AND CONSTRUCTION.
 6. EXISTING JAMB REINFORCEMENT SHALL BE FIELD VERIFIED. IF EXISTING CONDITIONS DIFFER FROM DETAILS ON SHEET S.501, CONTACT E.O.R.

PLAN REFERENCE NOTES:

- (A) VERIFY OPENING SIZE WITH MEP AND ARCH.
- (B) COORDINATE LOCATION WITH MEP/ARCH. OPENING LOCATION CAN MOVE ALONG EXTERIOR WALL TO A LIMITED EXTENT. VERIFY FINAL OPENING LOCATION IS ACCEPTABLE TO ALL PARTIES.
- (C) FRP SUBCONTRACTOR SHALL PROVIDE CALCS AND DRAWINGS WET STAMPED BY REGISTERED PROFESSIONAL ENGINEER WHO IS LEGALLY AUTHORIZED TO PRACTICE IN THE STATE OF ARKANSAS AND WHO IS EXPERIENCED IN FRP DESIGN.
- (D) THE ENGINEER OF RECORD WILL REVIEW THE CALCS AND SHOP DRAWINGS BUT THE REVIEW IS LIMITED TO CHECKING FOR GENERAL CONFORMANCE WITH THE DESIGN DRAWINGS.

LEGEND:

- (1) OPENING IN MASONRY WALL PER ELEVATION PER SHEETS S1.02, S1.03, AND S1.04.
- ###--- SEISMIC IN-PLANE SHEARWALL LOAD (LRFD)



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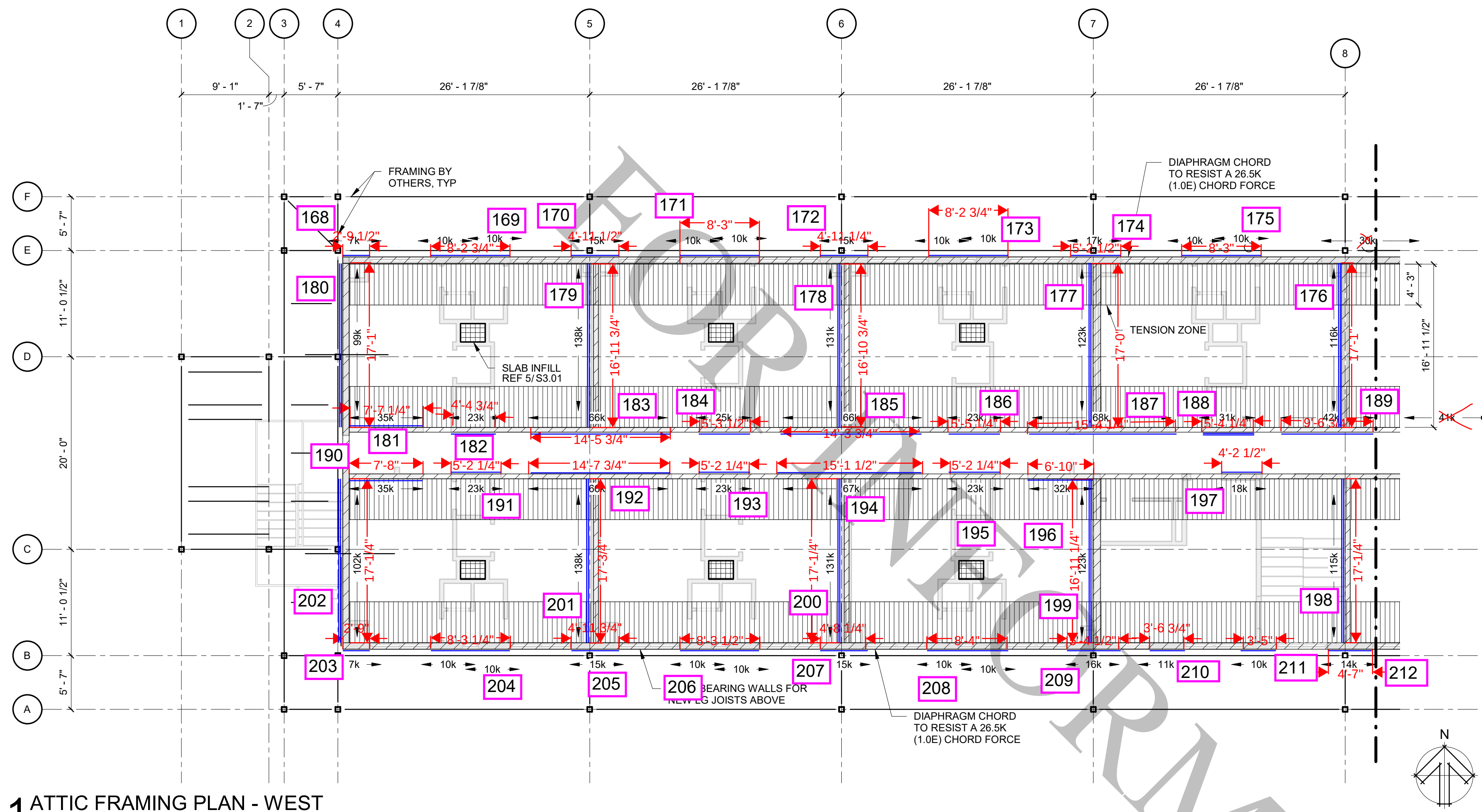
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PROJECT TITLE
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DORMITORY BLDG 854**

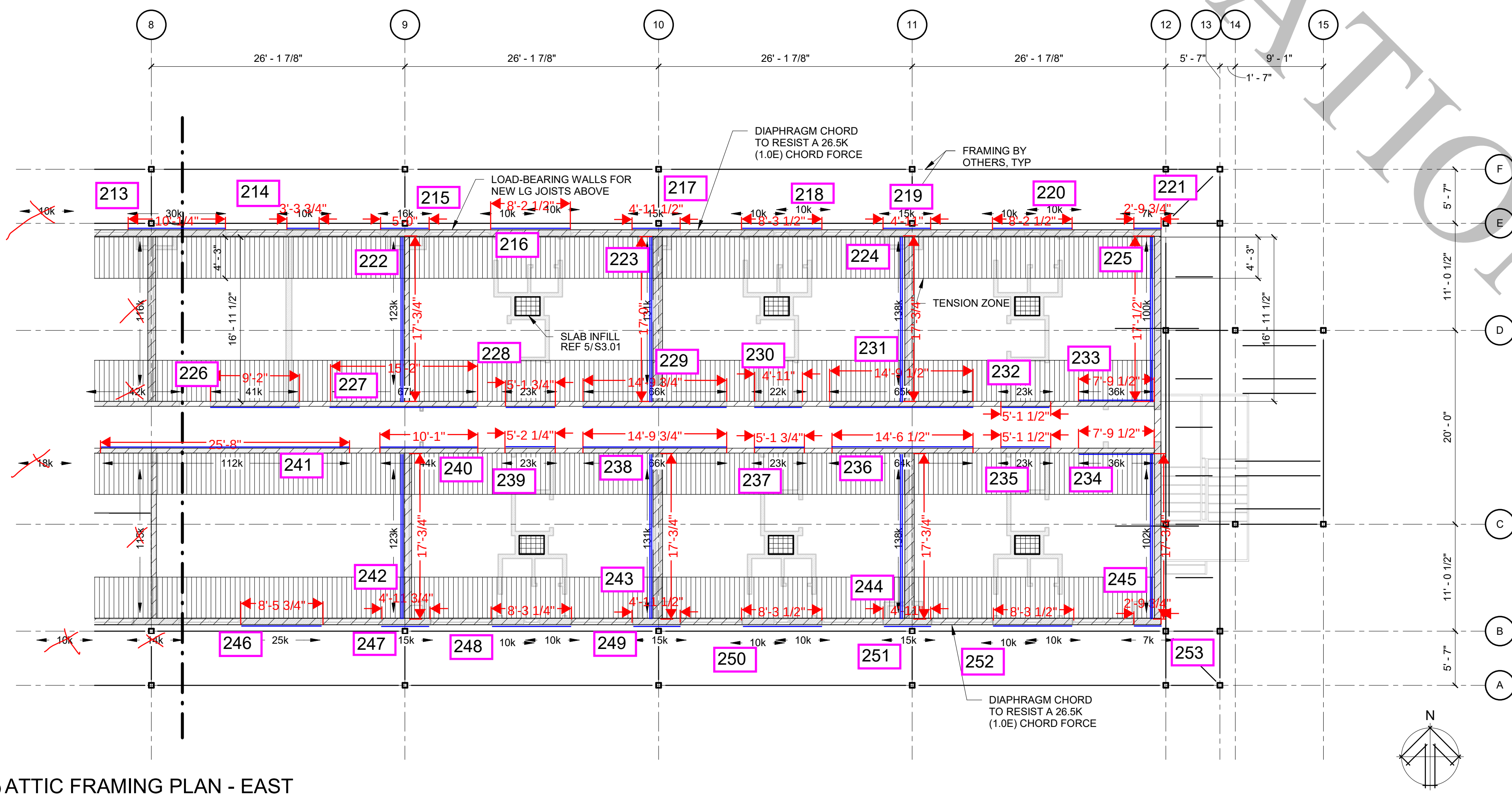
SHEET TITLE
THIRD FLOOR FRAMING PLAN

DRAWN BY AJG	SLAB DESIGNER AJG
TECH. REVIEWER JMG	PROJECT NUMBER NKAK 21-1034
DESIGNED BY AJG	SHEET
DATE 16 NOV. 2023	S1.03
SCALE AS NOTED	

95% PRE-FINAL DESIGN SUBMITTAL



1 ATTIC FRAMING PLAN - WEST
1/8" = 1'-0"



2 ATTIC FRAMING PLAN - EAST
1/8" = 1'-0"

- PLAN NOTES:**
- TOP OF FINISHED FLOOR ELEVATION = 111'-8 1/2" U.N.O.
 - CONTRACTOR SHALL NOT CUT, CORE, OR BORE HOLES IN EXISTING MEMBERS, INCLUDING MASONRY WALLS, HOLLOW CORE PLANKS, AND DECK, UNLESS APPROVED BY E.O.R.
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PLAN REFERENCE NOTES:

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- COORDINATE LOCATION WITH MEP/ARCH. OPENING LOCATION CAN MOVE ALONG EXTERIOR WALL TO A LIMITED EXTENT. VERIFY FINAL OPENING LOCATION IS ACCEPTABLE TO ALL PARTIES.
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LEGEND:

- OPENING IN MASONRY WALL PER ELEVATION PER SHEETS S1.02, S1.03, AND S1.04.
- ###--- SEISMIC IN-PLANE SHEARWALL LOAD (LRFD)



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No.	Revision/Issue	Date	BY	APP'D

PROJECT TITLE
**REPAIR (SUS) AIRMEN
DORMITORY BLDG 854**

SHEET TITLE
ATTIC FRAMING PLAN

DRAWN BY AJG	SLAB DESIGNER AJG
DESIGNED BY AJG	PROJECT NUMBER NKAK 21-1034
DATE 16 NOV. 2023	SHEET S1.04
SCALE AS NOTED	

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