STEWART STRUCTURAL ENGINEERING, PLLC

1485 Garland Hill Barnet, VT 05821 Tel: 802 633 3300 Fax: 802 633 4040

Project No. 752019

February 4, 2020

Ms. Karen E. Conroy, Superintendent.
Essex North Supervisory Union
318 Christian Hill
Canaan, VT 05903

Subject: Canaan Elementary School Roof

Karen,

At your request, I visited the Canaan Elementary School 01/10/20. The purpose of my visit was to observe suspected structural problems in the attic space of the subject school, determine if those conditions constituted structural deficiencies, and provide recommendations regarding repairs if found necessary. In addition to you and me, Eugene Reid, Building & Restoration CTE Instructor, Jim Reynolds, Head Custodian, and Dan Wade, School Board Chair were also present at the inspection. My inspection was limited in time and scope, and was not intended to be exhaustive or comprehensive. I inspected only a very limited area in the attic space of the classroom wing of the elementary school. Snow was present on the ground and on the roof, limiting exterior observations. I have appended a few of the photos I obtained that date, with annotation, for reference.

The subject school was reportedly constructed in 1960. You found and furnished me with scanned digital (pdf) copies of the original architectural and structural drawings for the building. These plans were produced by Heacock, & Platt Architects of Philadelphia, PA, and dated 03/10/60. As shown on those drawings:

- The predominantly one story classroom wing of the building has a typical school layout, with central corridor and classrooms on each side of that corridor. The corridor runs north-south.
- The roof is shallowly (3/8" per foot) pitched down over the classrooms toward the corridor, where roof drains were presumably located.
- The original roof framing consisted of structural steel beams and columns, and open web steel bar joists.
- Tectum roof panels span over the bar joists, with built up tar and gravel roofing on top of the Tectum.
- The bar joists span east-west over the classrooms and corridor, and are oriented perpendicular to the corridor.

Reportedly circa 2004, a new sloped roof system was installed on the entire elementary school building, on top of the original 1960 roof system. There are reportedly no surviving drawings or associated paperwork relating to this modification, and the responsible contractor is reportedly no longer in business. Based on my 01/10/20 observations in the attic space above the classroom wing, that new 2004 roof system consists of standing seam metal roofing applied directly on a system of light gage cold formed steel stud walls, which are installed on top of the original roof. At the classroom wing, the rows of cold formed steel stud walls run north-south. The rows vary in height from row to row to create the roof pitch, and the rows are spaced 4' o/c. The studs in each row are spaced 24" o/c.

Upon inspection of the school's attic space above the classrooms, it was apparent that the 2004 roof modifications had significant problems in the southeast quadrant of that section of the building. In the southeast quadrant, I found that the rows of cold formed steel studs had only a track (also called a "runner") section at the top of the studs, and that those track sections had buckled flanges which were significantly deformed, with the tracks sagging by as much as ¾" (estimated) between the studs. A very quick review of other nearby areas in the classroom attic revealed that the stud rows there had tracks that were reinforced with a strongback, an additional cold formed steel member. Where the reinforcement was present (reportedly the majority of the attic space above the classrooms), the tracks were not noticeably deformed or buckled. I have appended an excerpt from drawing # 2 of the 1960 architectural plans, showing the floor plan for the building. On that excerpt, I have hatched the currently known problematic area in pink, to identify its location. That area is about 36' wide east-west by about 50' long north-south. The area encompasses attic space from the current ridgeline eastward to the east eave, and from the south end of the classroom wing 50' northward to about the mid length of the wing.

Where the top tracks were found deformed in the southeast quadrant of the attic, the standing seam roofing had generally followed suit, and was similarly found sagging between the studs in each row. I observed some of the studs, and found them undeformed and undamaged. The standing seam roofing is attached to the top of the unreinforced tracks with clips which are screwed to the tracks. As is typical of standing seam roofing, the vertical legs of the clips are contained within the standing seams of the roofing, thereby concealing the clips from view. Such roofing is also referred to as a concealed fastener system, for that reason. In many instances observed, the standing seam roofing, although sagging, was found to have small and varying gaps between its underside and the top of the sagging track. This condition suggests that the roof has experienced heavier snow loads in the past, causing the track to deflect below the current sagging position of the standing seam roofing.

While on site, I made it clear that the sagging and buckled top track on the steel stud walls in the southeast quadrant of the classroom wing of the building represent a structural problem and deficiency. However, based on my observations, this condition did not appear to represent an imminent threat, but is serious, and does merit regular periodic observation by knowledgeable school personnel for changes, until repairs can be made. Because the standing seam roofing is applied directly on top of the steel stud walls, without benefit of any underlayment, sheathing, or insulation, condensation was present on the underside of the standing seam roofing. I asked if the moisture thus generated created any problems in the attic or classrooms below, and was told it did not.

While on site 01/10/20, I took measurements of the steel stud framing, but had not come equipped with a micrometer. A micrometer is necessary to measure the thickness of the cold formed steel members. Eugene Reid offered to come back with a micrometer, and obtain the thickness of the studs and tracks for me. He did so and found the studs are 40 mils thick (.040").

While in the attic, we also discussed the prudence of performing a general structural review of the original 1960 roof framing, to ascertain where it stands with regard to snow load capacity and compliance with current building code requirements for snow load. I explained that I had not yet had a chance to review the 1960 drawings other than superficially, and therefore did not know if those drawings contained information regarding the original structural design criteria for the building. It has been customary and required by code for decades that structural engineering drawings provide the criteria (loadings etc.) upon which the design is based, so that such information will be readily available in the future. Unfortunately, this was not the case in 1960. We discussed that if the 1960 drawings did not specify the building's original structural design criteria, that the drawings appeared to contain sufficient roof framing information to allow an engineering review and analysis of that framing, and that doing so could determine the roof's ability to sustain currently required snow loads. We consequently agreed that I would first review the 1960 drawings to see if they contained structural design criteria information, and if not, that I would then do the necessary engineering review and analysis to see if the original 1960 roof framing provides adequate load capacity to meet current building code requirements for snow load. I cautioned that the exact currently existing composition of the 1960 roof assembly was not known, and that a core sample would be required, to ascertain the roof assembly's composition and weight. Eugene Reid again offered to obtain the necessary core sample, did so, and mailed the sample to me. Of significant interest to me, was whether or not the original built up tar and gravel roofing had been removed in 2004, prior to the installation of the cold formed steel framing and standing seam roofing. I explained that any roof has a quantifiable TOTAL load capacity, and that that total is composed of snow load plus the weight of materials of construction of that roof. Hence, it is necessary to determine the weight of the materials of construction of that roof as accurately as possible, in order to determine that roof's snow load capacity.

Also while in the attic, we discussed possible repairs for the problematic cold formed steel framing in the southeast quadrant of the classroom wing. I pointed out that the deformed and sagging track sections over the top of the steel studs had not only sagged, but that the flanges of the tracks had also buckled. Buckling of steel is an inelastic and permanent deformation (damage). As such, a buckled steel framing member, whether heavy structural steel or light gage cold formed steel like the deformed tracks, cannot be structurally reconstituted by straightening. Replacement or reinforcement are generally the only two viable options for dealing with buckled members. We discussed that removing and replacing (R&R) the damaged track sections would require removal and replacement of the existing standing seam roofing in the affected area. I asked if that roofing was known to have any leaks or other problems, and was told it did not.

We consequently discussed possible reinforcement of the deformed tracks. It was suggested that the deformed tracks could be forced back into a straighter and less deformed geometry, and a new strongback added directly under the roofing and attached to the undamaged steel studs, mimicking what had been done in 2004 elsewhere in the attic. I pointed out that although the standing seam roofing was reportedly not problematic regarding leaks, that trying to force the roofing back into a straighter geometry with the tracks (because the roofing is attached to the tracks) might create leaks or other problems with that roofing. I emphasized that the sags in the roofing could not be straightened out independent of the sagging tracks, because the roofing is attached (screwed) to the tracks via the concealed clips mentioned earlier in this report. I also pointed out that the outwardly buckled flanges of the tracks, as well as the screws attaching those tracks to the existing studs, would interfere with attempting to locate a new strongback tight up against the underside of the roofing. We consequently discussed a scheme where the new strongback would be located below the track flanges, and a continuous but varying thickness shim installed on top of the strongback, to provide continuous bearing for the curved and deformed profile of the standing seam roofing. I suggested that a cement grout or possibly an epoxy product could be used as the shim, to provide for the required variable thickness. I further opined that while such a remediation scheme could likely be made to be structurally adequate, that removal and replacement of the roofing and damaged tracks would be the best solution. You asked me to look into both options, as the R&R option would likely be costly, and suggested that the repair option could probably be done by school staff, thereby minimizing costs.

I spoke with Dana Palmieri of Palmieri Roofing in St. Johnsbury on 01/21/20. Palmieri Roofing is a commercial roofing contractor. I asked Dana if he could provide a ballpark unit cost for budgeting purposes, for removing and replacing (with new) the existing standing seam roofing in the problem area at the school. Based on a piece of scrap roofing I obtained while in the attic, the existing roofing appears to be 24 gauge. Dana estimated about $12/SF for such work, but cautioned that he would have to physically inspect the job before providing an actual quote. Given that the affected area is about 1800 SF, the cost of R&R for the roofing would be about $22,000. That does not include the R&R of the tracks, addition of the new strongback, miscellaneous associated work, contingency, or contractor overhead and profit. Adding some ballpark estimates for those various other items, suggests that removal and replacement of the standing seam roofing and deformed tracks and adding in new strongback members would likely total somewhere in the vicinity of $50,000 to $60,000. I did not attempt to budget estimate the repair scheme for the problematic area of roof, as you had said that such work could likely be accomplished by school staff.

As the cold formed steel studs appeared undamaged, and would be reused in either the R&R or repair scheme herein described, I checked the load carrying capacity of those studs against the load that would be imposed upon them by the dead weight of the standing seam roofing plus the current building code required snow load. This first required determination of that code required snow load. Doing so requires a number of calculations, determinations, and the use of several documents, including the 2015 IBC (International Building Code), the 2015 Vermont Fire & Building Safety Code, and ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures". Due to the School's proximity to New Hampshire, I also consulted the US Army's Cold Regions Research and Engineering Laboratory's (CRREL) publication TR-02-6 "Ground Snow Loads for New Hampshire". Without burdening this report with the details and minutiae of the various calculations and qualifications required to arrive at the currently required roof design snow load for the subject school, suffice it to say that this was done, and the current required roof design snow load for the sloped roof framing system currently on the building is 50.8 pounds per square foot (psf). If a detailed explanation of how this number was derived is desired, I could of course provide such explanation. Based on this snow load, the existing sloped roof's materials of construction, and with no mechanical, electrical, or other equipment hung from or attached to the cold formed steel framing, I found that the existing light gage steel studs have adequate capacity to support the standing seam roofing and required snow load.

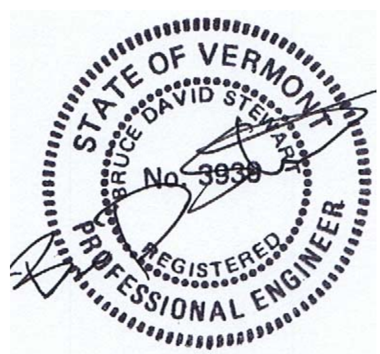
As discussed earlier in this report, I also checked a few representative members of the original (1960) steel roof framing, to see if they have adequate load carrying capacity to safely meet the current 50.8 psf snow load requirement. Applicable historical codes, specifications, and references in my library were utilized for this work, along with the core sample provided by Mr. Reid. It is worthy of note, that based upon that core, it appears that the original built up tar and gravel roofing was removed from the original roof in 2004, prior to installing the current sloped roof system. This finding is significant, as old built up roofing systems typically weigh between 6 and 8 psf. The removal of this old roofing removed more weight from the original roof than the new 2004 roofing system added. After reviewing the applicable historic reference documents and performing some basic structural engineering calculations, I found that, in general, the original 1960 steel roof framing has adequate capacity to support the current required snow load, the 2004 sloped roofing system, and an allowance of 10 psf for mechanical and electrical equipment in the classrooms, and 15 psf in the corridor (where most such utilities are typically located in schools).

I created and have attached several 8 ½ x 11 engineering sketches (SK's) to this report for reference. SK-1 and SK-2 are sections which depict the 1960 and 2004 roof framing systems, as they currently exist over the classroom wing. SK-3 shows the repair scheme described earlier in this report, but in more detail. I have not provided detailed material specifications etc., but could do so if you decide to move ahead with this scheme. As we discussed, I consider this scheme inelegant, but it will provide a structurally adequate repair. It should be noted that I investigated epoxy and other more high tech options for the variable thickness shim, but settled on the use of cementicious grout for cost and simplicity.

As stated earlier in this report, my 01/10/20 inspection was brief and quite limited in scope. With no surviving information regarding the 2004 roofing system, the question as to why the strongbacks were omitted in the southeast quadrant of the classroom wing may never be answered. However, it certainly begs the question of whether or not this situation (or other problems) exist elsewhere in the school. The remainder of the classroom attic and other attic areas of the school should therefore be inspected, to see if any other problematic areas exist with regard to the 2004 cold formed light gage steel framing. Given the meeting and school personnel present 01/10/20, it would appear that you have staff capable of doing such an inspection, at least as a preliminary screening. If any other problems or issues are discovered, we could first try mutually reviewing photographs of same. If photographs prove insufficient, then it would probably be necessary for me to make another site visit and inspection.

If I can be of further assistance in this matter, please contact me.

Sincerely,



Bruce D. Stewart, P.E., S.E.C.B.
Principal
Stewart Structural Engineering, PLLC

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SSE 01/10/20 INSPECTION PHOTOS

Looking south at the front of the school.

Looking southeast at the west side of the classroom wing.

Looking northeast in attic space in southeast quadrant of school, above classroom wing. Track (arrows) at top of light gage cold formed studs is unreinforced and deformed.

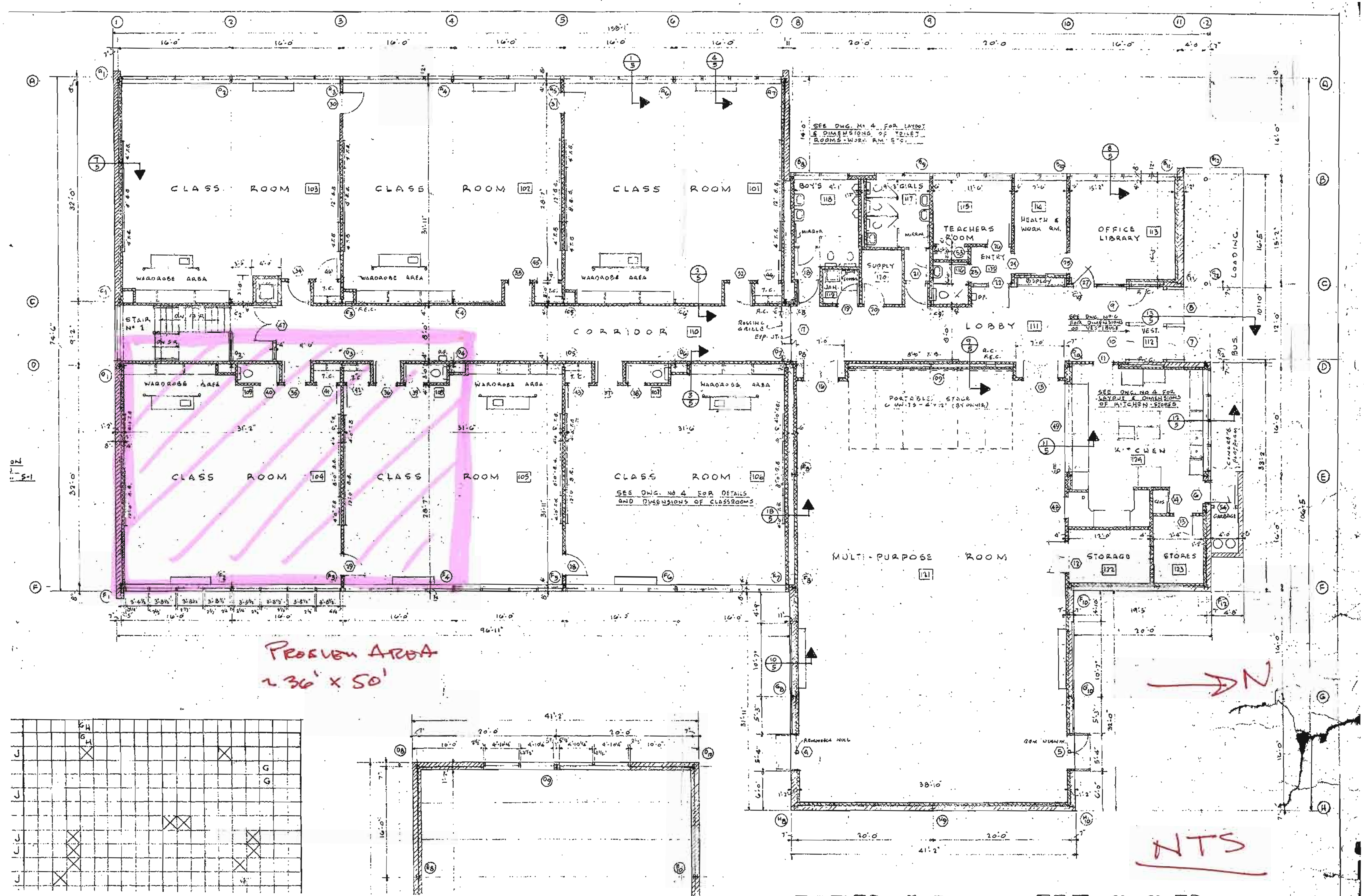
Looking east in attic space in southeast quadrant of school, above classroom wing. Tracks at top of light gage cold formed stud walls are unreinforced and deformed.

Looking south in attic space in southeast quadrant of school, above classroom wing. Tracks at top of light gage cold formed stud walls are unreinforced and deformed.

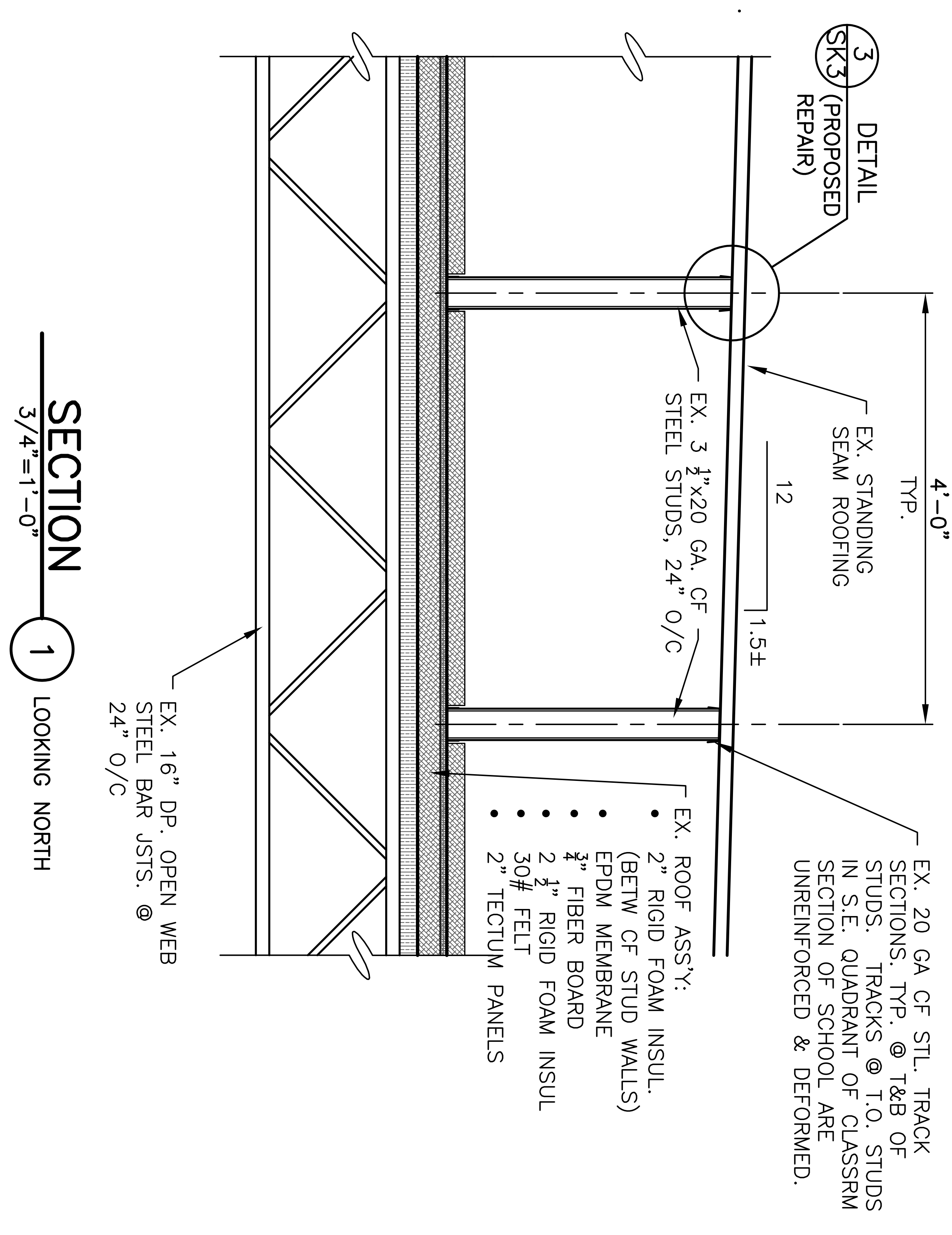
Closer view of deformed tracks at top of studs. Note gap (arrow) between underside of standing seam roofing and top of track.

Looking south in attic space near south end of classroom wing, directly under ridge cap. Rows of studs at right are in southwest quadrant of attic and are reinforced with strongback (another track section). Note condensation on underside of ridge cap and standing seam roofing to right.

EXCERPT FROM 1960 BUILDING PLANS SHOWING CURRENTLY KNOWN PROBLEM AREA HATCHED


CLASS ROOM 103
CLASS ROOM 102
CLASS ROOM 101
WARDROBE AREA
STAIR No 1
CORRIDOR 110
BOY'S 118
GIRLS 117
SUPPLY 120
TEACHERS ROOM 115
HEALTH & WORK RM. 114
OFFICE LIBRARY 113
ENTRY
LOBBY 111
VEST. 112
LOADING
BUS
CLASS ROOM 104
CLASS ROOM 105
CLASS ROOM 106
SEE DWG. No 4 FOR DETAILS AND DIMENSIONS OF CLASSROOMS
PORTABLE STAGE
MULTI-PURPOSE ROOM 121
KITCHEN 124
SEE DWG. No 4 FOR LAYOUT & DIMENSIONS OF KITCHEN-STORES
STORAGE 122
STORES 123
PROBLEM AREA
~36' x 50'
N
NTS

SSE SK DRAWINGS SHOWING EXISTING CLASSROOM WING ROOM FRAMING AND PROPOSED REPAIR DETAIL



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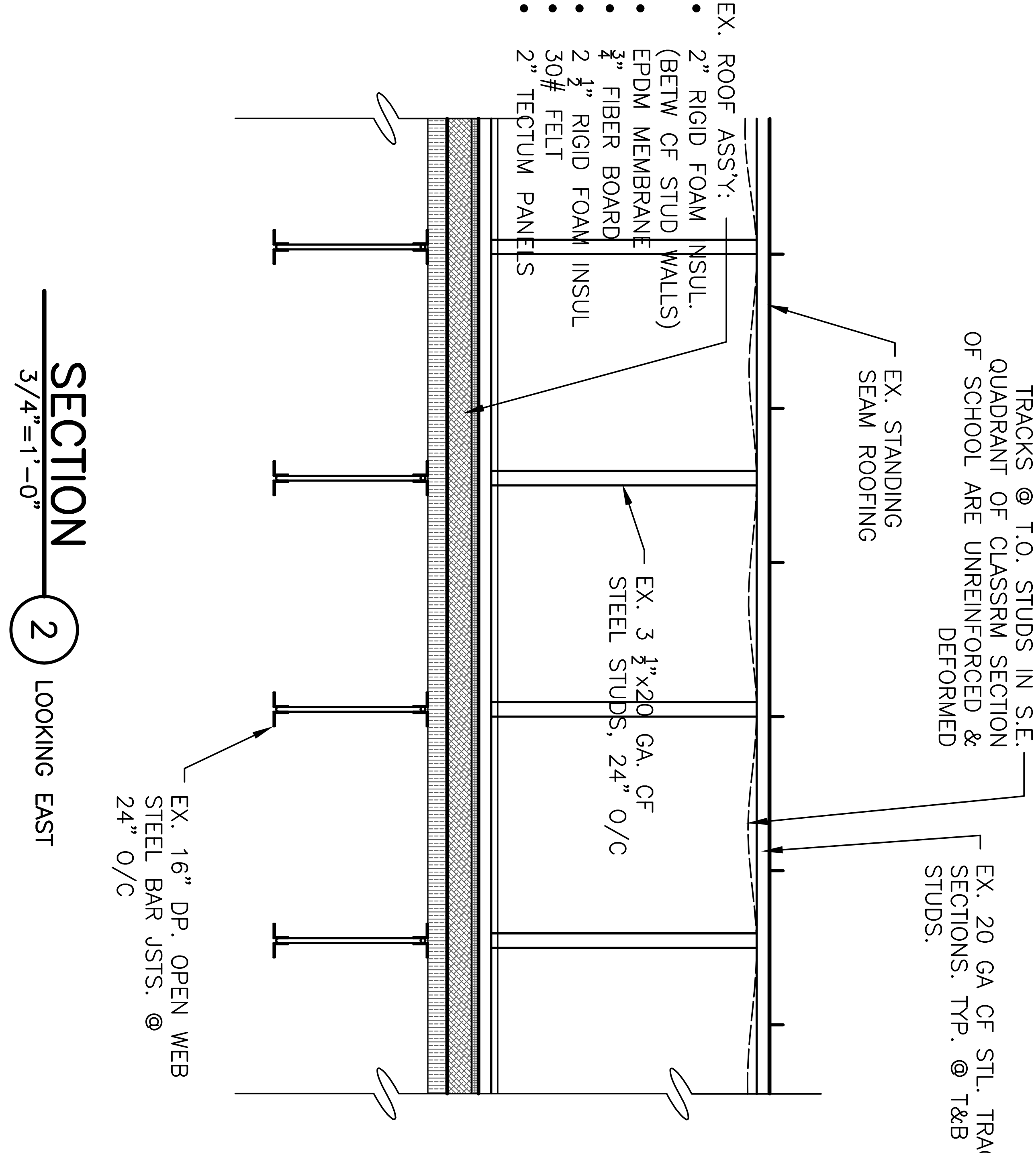
CANAAN ELEMENTARY SCHOOL
CANAAN, VT

SECTION THRU EX. CLASSRM. ROOF

SK–1

02–04–20



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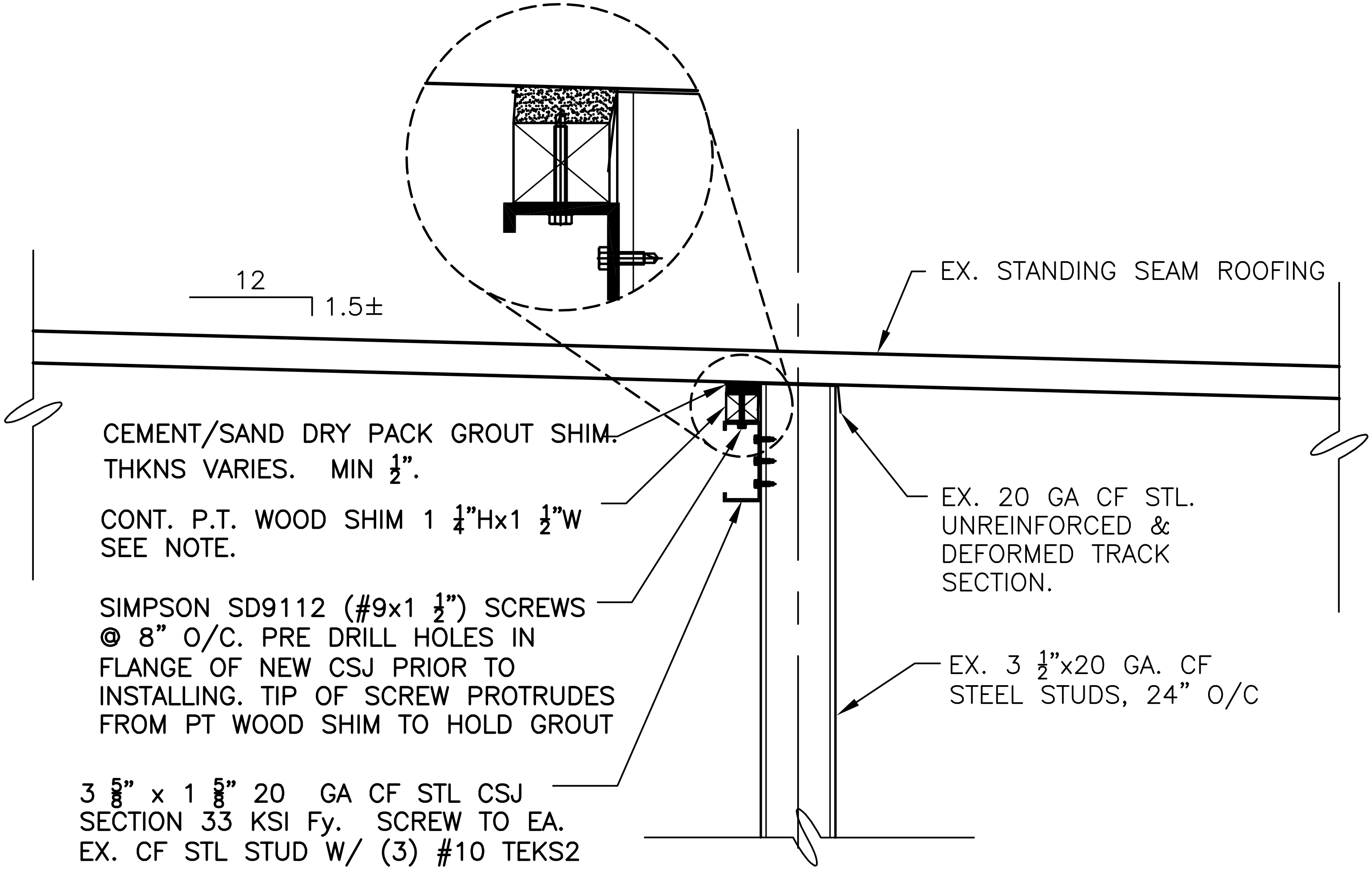
CANAAN ELEMENTARY SCHOOL
CANAAN, VT

SECTION THRU EX. CLASSRM. ROOF

SK-2

02-04-20



NOTE

LOCATE NEW CF STL CSJ SECTION JUST UNDERNEATH LOW PTS. OF DEFORMED TRACK FLANGE TO ALLOW SUFFICIENT ROOM FOR P.T. WOOD SHIM AND MIN ½" NS GROUT. SD9112 SCREW TIPS HAVE MIN ¼" CLEARANCE TO U'SIDE OF EX. ROOFING.

DETAIL (3)

1 1/2"=1'-0"

TYP. @ ALL ROWS OF CF STL STUDS WHERE TRACK IS UNREINFORCED AND DEFORMED.

CANAAN ELEMENTARY SCHOOL CANAAN, VT	SK-3
SECTION THRU EX. CLASSRM. ROOF	02-04-20

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