CROSS-US

Confidential Reporting on Structural Safety - US

STRUCTURAL ENGINEERING INSTITUTE

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Editorial from Directors Glenn R. Bell and Andrew Herrmann

Following its launch in 2019, CROSS-US continues to mature and gain momentum. Reports are flowing in, and from them our expert panel is extracting invaluable lessons; our readership community has expanded greatly; and we have corresponded with many companies and professional organizations interested in CROSS's mission. As an organization of the Structural Engineering Institute of ASCE, we are proud to participate in the expanding CROSS International community.

The reports of this newsletter remind us of the importance of keeping structural safety top of mind through study of the continuous flow of lessons from lesser failures, near misses, and other precursors, besides the less frequent catastrophic, news-making collapses. Each case reported has insights gained before but incompletely translated into enduring improved practice.

Reports US-07 and US-08 involve shortcomings in mandatory seismic retrofit projects for "soft-story" structures. Since the 1906 San Francisco earthquake, the US seismic community has done a fantastic job of learning from failures and translating those lessons into guidelines and requirements for better practice. Yet these two reports cite problems in the execution of regulations that seek to ameliorate lessons learned from the 1989 Loma Prieta earthquake. A similar example of failure to meet improved seismic regulations was previously reported in US-06. We are reminded to never relax our guard.

Reports US-04 and US-14 discuss the complexities and challenges of delegated design and the associated ethical dilemmas of professional responsibility. These issues were so tragically present in the 1981 walkways collapse of the Hyatt Regency Hotel in Kansas City.

US-10 describes a structural failure caused by a subsurface drainage problem. We must be ever mindful of the structural impacts of effects we may consider outside our normal purview – witness the 2017 Grenfell Tower fire disaster.

Finally, US-15 involves failure of a wood truss following a "nonstructural" renovation of an existing building. The dangers of inadvertent but critical modifications of structural elements in existing buildings were revealed in the 1972 collapse of the Hotel Vendome in Boston.

The success of CROSS hinges on our professional community. Please submit reports and encourage others to do so. Sign up for CROSS-US email alerts, be a student of CROSS lessons, and encourage this in your organization, so we may translate lessons into improved practice. We are interested in collaboration with other professional organizations who have interest in the mission of CROSS-US.

Glenn and Andy

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CROSS-US

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HOW TO REPORT

For more information, please visit the How to Report> page.

If you have experienced a safety issue that you can share with CROSS-US, please Submit a CROSS-US Report> If you want to submit a report by post, please send an email to administrator@cross-us.org> asking for instructions.

KEY

Ⓡ CROSS-US REPORT

Ⓒ CROSS-US PANEL COMMENTS

Ⓝ NEWS

Ⓘ INFORMATION

> DENOTES A HYPERLINK

US-04: Bottom-chord bracing for metal plate-connected wood trusses used in light commercial applications, Report ID: 865

OVERVIEW

Concerns regarding metal plate-connected wood trusses in light-commercial construction when subject to net uplift

Ⓡ REPORT

A reporter is concerned about metal-plate connected wood trusses in light-commercial construction – specifically the use of these trusses with no ceiling (exposed trusses) or a suspended ceiling grid. These light-framed roofs will typically experience a net uplift even under moderate wind loading, which will cause the bottom chord to go into compression to resist the net uplift. These bottom-chord compression members almost-always require bracing to achieve adequate strength – similar to columns. Generally speaking, on light-commercial jobs, the Building Designer will defer to the Contractor, Truss Manufacturer, and Truss Designer[1] to provide temporary and permanent bracing, and the Truss Manufacturer/Designer will only provide the typical details – such as in BCSI-B3[2], if at all. Truss Manufacturers/Designers should pay attention to the architectural drawings and the reflected ceiling plan to see if additional bracing is needed to resist net uplift loads. The Building Designer must coordinate bracing for these components, as it is part of the structural load path. Unfortunately, the scope of services on most light-commercial projects are lacking requirements for parties to coordinate between disciplines, which leaves many of these structures susceptible to wind-uplift related failure.

Ⓒ COMMENTS

The typical governing standard for this construction is ANSI/TPI 1[3] as referenced by the applicable edition of the International Building Code (IBC). Wind uplift pressures are prescribed by ASCE 7 and the IBC in the United States.

A failure from the conditions noted is usually related to a lack of coordination and confusion about the responsibilities of the various entities, particularly the Building Designer, the Contractor, the Truss Manufacturer, and the Truss Designer.

The Building Designer is ultimately responsible for the design of the overall building structure. Design can be delegated but overall responsibility cannot. The issue reported here is not one of building codes or material selection, but rather of the failure of the Building Designer to review the delegated design work, and to reasonably ensure that their design intent has been achieved in the field.

A failure from the conditions noted is usually related to a lack of coordination and confusion about the responsibilities of the various entities, particularly the Building Designer, the Contractor, the Truss Manufacturer, and the Truss Designer.

Local building officials generally rely on the Building Designer to provide a complete structural load path. Some jurisdictions may not check and/or peer review light commercial construction and rely on a design presented in submitted engineering drawings to provide a minimum level of structural performance during a wind event.

ANSI/TPI 1 Para. 2.3.3.1 allows methods of restraint/bracing of trusses and their members to be accomplished by standard industry details, substitution with reinforcement, or project-specific design. This breadth of approach allows for specific determination of such bracing by the Structural Engineer of Record (SEOR) or Truss Design Engineer, requiring care in communication amongst parties involved in the bracing design and installation.

1 Titles of responsible parties mentioned herein follow Ref. 3. Note that on most projects the Building Designer is the Registered Design Professional or Structural Engineer of Record.
2 BCSI is Building Component Safety Information, which is published by the Structural Building Components Association.
3 ANSI/TPI 1 – 2014, National Design Standard for Metal Plate Connected Wood Truss Construction.

Ⓝ NEWS

We are excited to welcome two new members to our expert Panel: Craig Durgarian, Assistant Vice President with Zurich North America – Insurance and Risk Management, and Eric Herbert, Structural Bridge Engineer with Kiewit Infrastructure Engineers. You can find their bios on the >people page of the CROSS-US website.

Ⓝ NEWS

Since publication of CROSS-US Newsletter No. 1, these other newsletters have been published by the CROSS international community: >UK59 and >AUS4.

Ⓘ INFORMATION

CROSS-US is happy to provide special virtual presentations to your company or professional association on how CROSS works and how you may benefit from its use. Contact Glenn (glenn@cross-us.org) or Andy (andy@cross-us.org).

Ⓘ INFORMATION

We are grateful to the reporters who contributed to this newsletter for their time and initiative in sharing their experiences with others.

The CROSS-US Panel unselfishly offered their expert advice in preparation of comments for the reports.

Alastair Soane and Paul McNulty of Structural-Safety.org have been invaluable and generous with their time in the continued development of CROSS-US.

ANSI/TPI 1 Para. 2.3.2.4 contains a detailed list of information required of the Construction Documents for the truss design and the supply of related Structural Elements, including specification of all loads on the trusses. Para. 2.3.4 requires the Contractor to provide all relevant documents to the Truss Manufacturer. This information must be, in turn, transmitted to the Truss Designer. Overestimation of deadload can be unconservative in determination of net uplift, so the Building Designer and the Truss Designer must be clear in communicating and understanding what deadloads are applied in various locations. (For example, some portions of a building may have ceilings, and some may not.) In these cases, provision of a complete set of design drawings (not just structural) to the Truss Designer is helpful.

ANSI/TP 1 Para. 2.3.1.6.2 requires Special Inspection, including of restraint and bracing, but only for clear spans of 60 ft (18.3 m) or more. For lessor spans, which would include significant light-commercial construction that is the subject of this report, field observations by the Building Designer are especially important.

Limited scopes of services mentioned by the Reporter, while unfortunate, cannot be an excuse by the parties involved. The best designs, details, etc. are of little value if coordination and follow through do not take place at the critical times during the project life.

This report is about light-commercial design. This also applies to residential or any project without sufficient bottom-chord bracing.

Additional references[4,5,6] are included below.

SUBMIT REPORT>

SUBMIT FEEDBACK>

4 Josh Bartlett, "Wood Truss Bracing, whose Job is it Anyway?", STRUCTURE, March 2005 (https://www.structuremag.org/wp-content/uploads/2014/09/bracing-issues1.pdf).

5 The Truss Plate Institute publishes standards and guidelines on this subject: (https://www.tpinst.org/technical-downloads).

6 Metal Plate Connected Wood Truss Handbook, Wood Truss Council of America.

US-07: Inadequate design and quality assurance on a mandatory seismic retrofit project, Report ID: 887

OVERVIEW

Tenant's structural engineer discovers widespread design and related quality problems on a mandatory seismic retrofit project.

Ⓡ REPORT

This case involves design problems and inadequate quality assurance on a mandatory seismic retrofit for "soft story"[7] deficiencies in a city in Northern California[8]. Despite the problems identified, both the design and the completed construction were approved by the city. The problems were found only when a tenant requested that the reporter make a review of the work for unrelated purposes. The retrofit plans do not match the building. Critical shear wall locations are shown on the retrofit plans with orientations and lengths that do not match actual conditions. An existing bay window is shown straight. An existing lightwell is omitted. Existing basement/foundation walls are shown as concrete but are, in fact, unreinforced brick. Plans include details only for full-height shear walls when the actual walls are much shorter due to basement/foundation wall height. Retrofit shear walls have incorrect orientation, height, tie-down locations, anchor types, and anchor capacities. The contractor appears to have improvised changes to suit the actual conditions without consulting with the design engineer or filing required revision sketches. The project went through city plan review and inspection processes flagging none of these errors, and the city generated a certificate of final completion.

Severe inadequacies in the LDP's retrofit plans were exacerbated and perpetuated by the contractor's improvisation, which was further perpetuated by inadequate field observation by the LDP and inspection by the city.

Ⓒ COMMENTS

The building that is the subject of this report was under a mandatory city retrofit program, which is specific in its evaluation and retrofit requirements. Unfortunately, numerous quality shortcomings in design, construction, and field observation resulted in a retrofit that failed to provide the desired performance improvements.

The report offers incomplete detail on how the quality problems on this project occurred because the reporter was not the retrofit designer and learned of the problems only after construction was completed. An appropriately Licensed Design Professional (LDP) must evaluate the existing conditions and design a retrofit to meet the ordinance requirements. Typically the LDP must observe the retrofit construction at intervals appropriate for the work (there are some exceptions to this) and "sign off" at project completion that the work substantially complies with the LDP's design documents. Such requirements were part of the ordinance of this project's jurisdiction. The LPD's plans reportedly do not match the existing building. The reporter notes that the contractor improvised to suit field conditions rather than consulting the LDP about how to deal with discrepancies between the drawings and field conditions. While not absolving the LDP and contractor of their responsibilities, the

7 "Soft story" is a technical term defined in US codes and standards related to seismic evaluation and design. Generally, it refers to a structural irregularity, often related to architectural features, in which one or more lower stories of a building are substantially less stiff in seismic resistance than stories above. Soft-story (and similar "weak-story") effects make buildings seismically vulnerable and have resulted in failures or collapse of buildings in earthquakes. While the term is generic with respect to structural systems and materials, past earthquakes in California caused multiple failures of wood residential buildings where the first story was "soft" or "weak" due to open spaces for car parking or large openings in perimeter wall lines for garage doors and storefronts. Recognizing this, several jurisdictions in California have implemented mandatory retrofit programs for soft-story vulnerability. Understandably, but contrary to the engineering standards, these jurisdictions use "soft story" as a shorthand term to mean wood residential buildings of a certain size and age, typically built before 1980, and having at least three residential units. This report reflects that shorthand usage. San Francisco's ordinance is here: https://sfdbi.org/softstory. Los Angeles' requirements are here: https://www.ladbs.org/services/core-services/plan-check-permit/plan-check-permit-special-assistance/mandatory-retrofit-programs/soft-story-retrofit-program.

8 For confidentiality, the city is not identified herein.

city's department of building inspection had responsibility to review the LDP's drawings and inspect the work before issuing a certificate of final completion. The plan review might not have caught the discrepancies between the plans and the existing conditions, but a final inspection should have. Severe inadequacies in the LDP's retrofit plans were exacerbated and perpetuated by the contractor's improvisation, which was further perpetuated by inadequate field observation by the LDP and inspection by the city.

SUBMIT REPORT>

SUBMIT FEEDBACK>

US-08: Mandatory seismic retrofit construction with quality control problems, Report ID: 888

OVERVIEW

Standard seismic retrofit details were used for a building with non-standard foundation.

Ⓡ REPORT

Project plans use common details for retrofit of a wood residential building with a "soft story"[9] deficiency, including additional wood structural panel sheathing and tie-downs applied to existing studs over an existing concrete foundation. However, the actual building has brick foundations. Anchor bolts have been installed into the brick foundations per the concrete detail, but there is no record of a requirement for testing or inspection, which should have caught this discrepancy.

Ⓒ COMMENTS

The building that is the subject of this report was subject to a mandatory city retrofit program[10], which is specific in its evaluation and retrofit requirements.

A competent retrofit engineer should have verified all existing conditions, or required the verification by a qualified third party, including the foundation type and condition, before beginning design work.

The report describes a standard seismic retrofit being performed on a non-standard brick foundation. A competent retrofit engineer should have verified all existing conditions, or required the verification by a qualified third party, including the foundation type and condition, before beginning design work. Brick foundations, which are uncommon for the location and building type described, are typically unreinforced and have little or no strength except in compression. They are typically inadequate to resist the shear and overturning forces associated with a retrofit design. The reporter correctly points out that a requirement for testing of the anchor bolts would have caught the discrepancy between the drawn concrete foundation and actual brick foundation. Testing is not always required if the code has default values for existing bolts, but it should have been required because of the atypical brick conditions.

SUBMIT REPORT>

SUBMIT FEEDBACK>

9 For discussion of the term "soft story" see footnotes of Report US-07.

10 For confidentiality, the city is not identified herein. For further discussion of soft-story ordinances, see footnotes of Report US-07.

US-10: Under slab perimeter drain failure, Report ID: 907

OVERVIEW

Foundation, wall, and basement slab settlement damage due to high water table and layers of subsurface fine (sugar) sand.

Ⓡ REPORT

Local homeowners were experiencing movement and settlement of foundations, walls, and slabs after installing interior perimeter wall drains with sump pumps in their basements in response to water infiltration due to recent high-water tables. Under-slab perforated pipe drains wrapped in filter fabric are a standard method of groundwater control. The area that is the subject of this report has large deposits of fine (sugar) sands, which migrate through the standard filter fabric and are pumped out to the discharge area resulting in loss of soil beneath the footings and slabs, causing settlement and damage to foundations, basement walls, and slabs.

A solution was provided for local municipality ordinance consideration to use filter fabrics with Apparent Opening Sizes of a #100 sieve and a surrounding layer of poorly graded course sand (e.g., Soil Classification SP) around the perforated pipe to prevent the fine (sugar) sands from migrating into the pipe and thereby stopping the erosion of the soil beneath the foundation and slab.

Ⓒ COMMENTS

The report describes how a common solution to a rise in water table elevation to prevent water in a basement did not work in an area with fine sand layers.

The solution proposed seems appropriate, at least in concept, but it should be reviewed and approved by a competent geotechnical engineer. There are other possible solutions, such as waterproofing by chemical injection just beneath the basement floors and just outside the basement walls. Chemical injection might also be a method to arrest, and perhaps to reverse, the observed settlement.

Additional references[11,12] are included below.

SUBMIT REPORT>

SUBMIT FEEDBACK>

11 A guide to footing drain pipes: https://basc.pnnl.gov/resource-guides/footing-drain-pipe.

12 Bulk Water Control Methods for Foundations (https://www.buildingscience.com/sites/default/files/migrate/pdf/BA-1015_Bulk_Water_Control.pdf).

US-14: Structural Engineer faces ethical dilemma, Report ID: 943

OVERVIEW

Engineer's professional obligations in delegated designs.

Ⓡ REPORT

A correspondent reports being placed in a difficult ethical situation. The correspondent is a structural engineer working on a delegated design that is part of a new structure. During its work, the correspondent discovered what it considers to be serious safety flaws in the structure's base design. The correspondent has worked extensively to bring these issues to the attention of various project participants, but they remain unaddressed. The correspondent desires an industry system to "whistle blow" in this situation. The correspondent asks if there is a way to meet its professional obligation to public safety without fear of repercussion.

Ⓒ COMMENTS

This report brings up the responsibility of an engineer when he/she believes they have found serious safety flaws in a base design by others on a project for which they are providing delegated design.

Engineering licensing boards in all US jurisdictions require their licensed engineers to hold public safety paramount in all that they do. Many licensing boards provide rules that explicitly direct their licensees in situations such as that described by this reporter.

In this example, the reporter should bring the safety flaws to the attention of the prime professional. If the flaws are not appropriately remedied, the reporter should bring them to the attention of the contractor. If the flaws are still not remedied, the reporter should bring them to the attention of the project owner. If the flaws are still not remedied, the reporter should bring them to the attention of the building official or government agency having jurisdiction. In some circumstances it may be necessary to report the issue to the licensing board. Each notice should be made or documented in writing.

Public safety is paramount to the practice of engineering.

Will there be repercussions? There may be, but that should never be a deterrent. Public safety is paramount to the practice of engineering.

Additional references[13,14] are included below.

SUBMIT REPORT>

SUBMIT FEEDBACK>

13 ASCE Code of Ethics (https://www.asce.org/code-of-ethics).
14 NSPE Code of Ethics (https://nspe.org/resources/ethics/code-ethics).

US-15: Failure of existing long-span wood roof truss following installation of new roof-top HVAC units, Report ID: 949

OVERVIEW

Failure of an existing long-span wood roof truss following installation of new roof-top HVAC units offers lessons in the special challenges of renovations to existing buildings.

Ⓡ REPORT

An existing wood roof truss failed after several new HVAC (Heating, Ventilating, and Air Conditioning) units and associated piping and ductwork were added on the roof of an existing building during a renovation project.

The renovation project team had proceeded without the involvement of a structural engineer (SE) until the building department required that an SE evaluate the structure and design modifications, if needed. The late engagement of the SE in the process caused significant schedule pressures. The SE visited the project site to understand the existing conditions and to discuss with the owner's representative the intended renovations. Significant in this visit was an observation that ceilings were self-supporting on bearing walls, and there was minimal load from ceilings and MEP (Mechanical, Electrical, and Plumbing) equipment suspended from the roof. The SE noted no deterioration of the trusses. The owner's agent at the site represented that in the renovations, ceilings would continue to be independently supported (not off the trusses), and that the minimal suspended load on the trusses would not be increased. The mechanical engineer provided the weights of new mechanical equipment to the SE. The SE was never provided final design documents from the architect or the MEP consultant. The SE determined that the increased load from the new HVAC units represented a less than 2% increase in the demand/capacity ratio of the wood trusses, and so concluded that no remedial work to the trusses was required. The SE prepared and submitted a structural design drawing indicating subframing support for the new HVAC units.

During construction administration, the SE received a submittal from the mechanical contractor corroborating the HVAC unit weights provided to the SE orally. The SE made one construction observation site visit. While the HVAC subframing appeared to generally conform with the SE's drawings, they noted that several studs from pony walls atop the trusses in the original construction had been removed (Figure US-15-1). The trusses were of "bowstring" configuration, and since the arc of the top chord is below the flat roof deck, "pony" stud walls supported the roof deck off of the trusses and special lateral bracing of the trusses' top chords

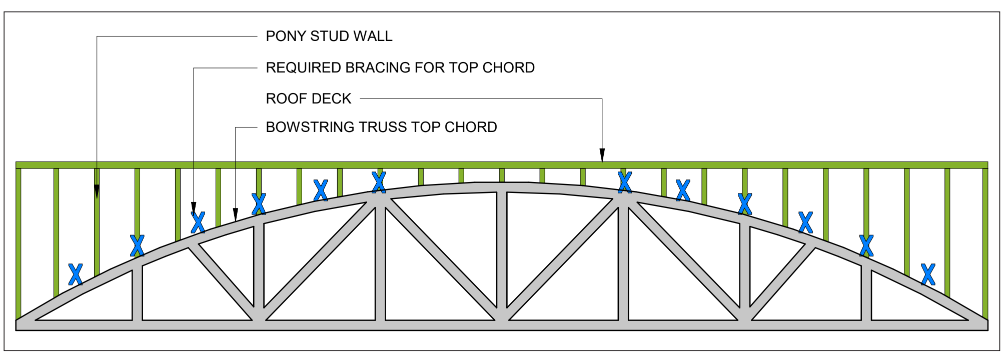

Figure US-15-1: Figure drawn by REM Arch LLC.

were required. The SE provided a sketch to remediate the pony walls.

Several months later, the SE received a phone call indicating that the trusses were failing, and the roof was collapsing. The SE went immediately to the site and noted two important facts. First, several lateral braces of the pony wall above the trusses near the truss ends had been removed during the recent construction and had not been reinstalled. No notification of the removal of these braces was ever provided to the structural engineer. These lateral braces were required because near the ends of the trusses, the top chords were not directly connected to the roof diaphragm and therefore the top chords were not laterally braced without the extra lateral brace members (Figure US-15-1). Second, although the SE had asked and been told that the ceiling would not be supported by the roof structure, it had, in fact, been hung directly from the roof. The amount of ductwork and piping was significantly more than was expected by the SE during the evaluation and design.

C COMMENTS

This case study highlights many challenges of renovating existing structures. Such work must consider (1) the existing loads on the structure and how the renovations may change those loads (2) any changes in design loading required by code updates, and (3) the existing capacity of the structure, which involves understanding the in-place structural conditions, including possible deterioration and structural changes brought about by the renovation. The contractor may also inadvertently change existing conditions during construction it considers structurally insignificant, but that are critical. These and other factors are discussed below.

The project's overarching conditions were an invitation for problems.

Existing conditions: During the "design" phase of the project the structural engineer made one site visit to observe the existing construction and to understand, based on a verbal report from the building owner's representative, the intended scope of renovation. There were apparently no original design drawings available. Lack of original design drawings increases the need for documentation of the existing construction. Visibility and close-up access to existing conditions can be a challenge. The structural engineer's observation that bracing of the trusses' top chords required special care in this configuration is to be commended.

Unfortunately the structural engineer was never provided renovation design drawings. The entire process relied on verbal communication of design intent that appears not to have been documented in detail. This lack of documentation in conjunction with an apparent lack of final inspection and signoff at the completion of construction (see below) were two critical factors in this failure. Of note is that the ceiling and mechanical equipment hung loads were significantly greater than the SE understood they would be.

The applicable building code for this project did not require that the renovated existing building comply in all respects with current codes for new construction, as is typical for minor renovations. The structural engineer's threshold check that if loads were not increased more than 2% then the renovation had negligible load impact on the trusses appears reasonable.

The contractor made debilitating changes to structural conditions without SE's knowledge, most significantly removal of studs from the pony wall and removal of truss chord bracing. It is, unfortunately, not uncommon that contractors take liberties with structure during MEP work. To prevent this for wood construction the International Building Code[15] states: 2303.4.5 Alterations to trusses.

"Truss members and components shall not be cut, notched, drilled, spliced or other altered in any way without written concurrence and approval of a registered design professional. Alterations resulting in the addition of loads to any member (for example, HVAC equipment, piping, additional roofing or insulation) shall not be permitted without verification that the truss is capable of supporting such additional loading."

Construction observation and signoff: A final safeguard against the failure reported would be inspections by the SE and the building department at the completion of construction.

While the SE did make one site inspection during construction, critical changes to the structure and the loads imposed on it were made after the SE's visit.

Time pressures and scope of the SE's involvement: The project's overarching conditions were an invitation for problems. That the SE was introduced to the project late in the process (1) shows a lack of appreciation amongst other members of the project team for structural implications of the work and (2) caused the work to be hurried. The report does not indicate that a single prime design consultant was in charge. Communication between project team members was not clear. Documentation was poor. While it is not uncommon for top-down budget considerations to limit an SE's involvement on projects where the apparent structural component to the work seems small, where structural safety is concerned the project structural considerations must not be compromised.

There was a catastrophic collapse of the Sampoong Department store in South Korea in 1995 due to a variety of causes and 500 persons died. There were several deficiencies, one of which was the re-positioning of heavy HVAC units on the roof[16].

SUBMIT REPORT>

SUBMIT FEEDBACK>

15 International Building Code, 2018 Edition, International Code Council.

16 https://safety.productions/2019/02/17/sampoong-department-store-collapse-south-korea/.

PARTICIPATION

The success of the CROSS-US scheme depends on receiving reports, and individuals and firms are encouraged to participate by sending reports on safety issues in confidence to **CROSS-US>**.

FEEDBACK

If you have any comments or questions regarding this CROSS-US newsletter, please submit feedback to **glenn@cross-us.org>** and **lchampion@cross-us.org>**

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