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DIGITAL CONSTRUCTION SAFETY CONFERENCE

CONCRETE CONSTRUCTION SAFETY ISSUES:

Formwork, Blow-outs, Pumping Ops, Shoring & NYC Registered Concrete Labs

PRESENTED BY

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PRESENTATION OVERVIEW

- This presentation will provide an overview of the latest NYC Building Code requirements for concrete construction and formwork in accordance with the 2014 Building Code Chapters 19 and 33. Case studies will utilized to demonstrate construction-related failures, incidents and overall dangerous conditions commonly found by the Concrete Enforcement Unit including formwork failures related to neighboring buildings and the general public safety. Also, the presentation includes guidelines on how to work with the Concrete Enforcement Unit on design, construction and special inspections related issues that may arise during the course of design or construction of a project.

CONCRETE ENFORCEMENT UNIT

- The **Concrete Enforcement Unit (CEU)** is a legislative unit within the Department's **Investigative Engineering Services** division.
- CEU is responsible for oversight of all concrete structural placements, inspections of concrete formwork, auditing of concrete testing laboratories, performance of concrete parallel testing and the review and approval of concrete mix design and inspection reports throughout the five boroughs.
- CEU is comprised of specially trained inspectors, engineers and administrators.
  - All CEU inspectors and engineers are ACI trained and certified

CONCRETE ENFORCEMENT UNIT

- **Legislative Responsibilities**

  Field Inspections

  - Structural inspections and Site Safety inspections of all buildings nine stories and under.
  - Structural inspections of all buildings ten stories and up (CSC/CSE responsible for site safety of major buildings).
  - Parallel Testing – compressive cylinders taken on site and tested at Port Authority Lab. CEU engineers compare test results from PA with testing lab results.
  - TR2/TR3 forms, referrals from industry and other DOB Units (CSC/CSE).

CONCRETE ENFORCEMENT UNIT

- **Legislative Responsibilities**

  Concrete Lab Inspections

  - Random twice annual inspections of all NYC registered concrete testing labs.
  - Check staff and management licensure and certification.
  - Review Quality Manual and example of field/testing report produced by lab.
  - Review lab records for equipment calibration.
  - Witness a compression test
  - Inspect that concrete cylinders are stored properly

CONCRETE ENFORCEMENT UNIT

- **Legislative Responsibilities**

  Engineering Audits

  – Pre-Permit Reviews
    - Checking proper completion of applicable TR forms (TR1, 2, 3, 4, 5, 5H and 8)
    - Check for approved plans filed and available through BIS *(Now using DOB NOW)*

  – Review of Structural and Architectural Drawings
    - Plan Review
    - Framing layout
    - Special inspection list (Coordinate with TR1)
    - Structural design variables (NYCBC CH 1603)
    - Approved reference materials and editions (NYCBC Ch 35)
    - Coordination with architectural plans and surveys
    - All required information for construction or to allow for subsequent shop drawings.

CONCRETE ENFORCEMENT UNIT

- **Legislative Responsibilities**

Engineering Design

- Gravity design
- Lateral systems design
- Deflections and building separations

Engineering Audits

- Post-Permit Reviews
  - Special Inspections
    - Checking for Special Inspection license and proper certification for all inspectors
    - Checking for coordination of required inspectors as per structural plans and filed TR1 forms
    - Checking reports for full documentation of inspections performed including dates of inspections, plan/detail references, photos and other required elements as outlined in 1 RCNY-101-06(b)(4)
    - Checking reports for proper certification, stamps and signatures, as needed.

CONCRETE ENFORCEMENT UNIT

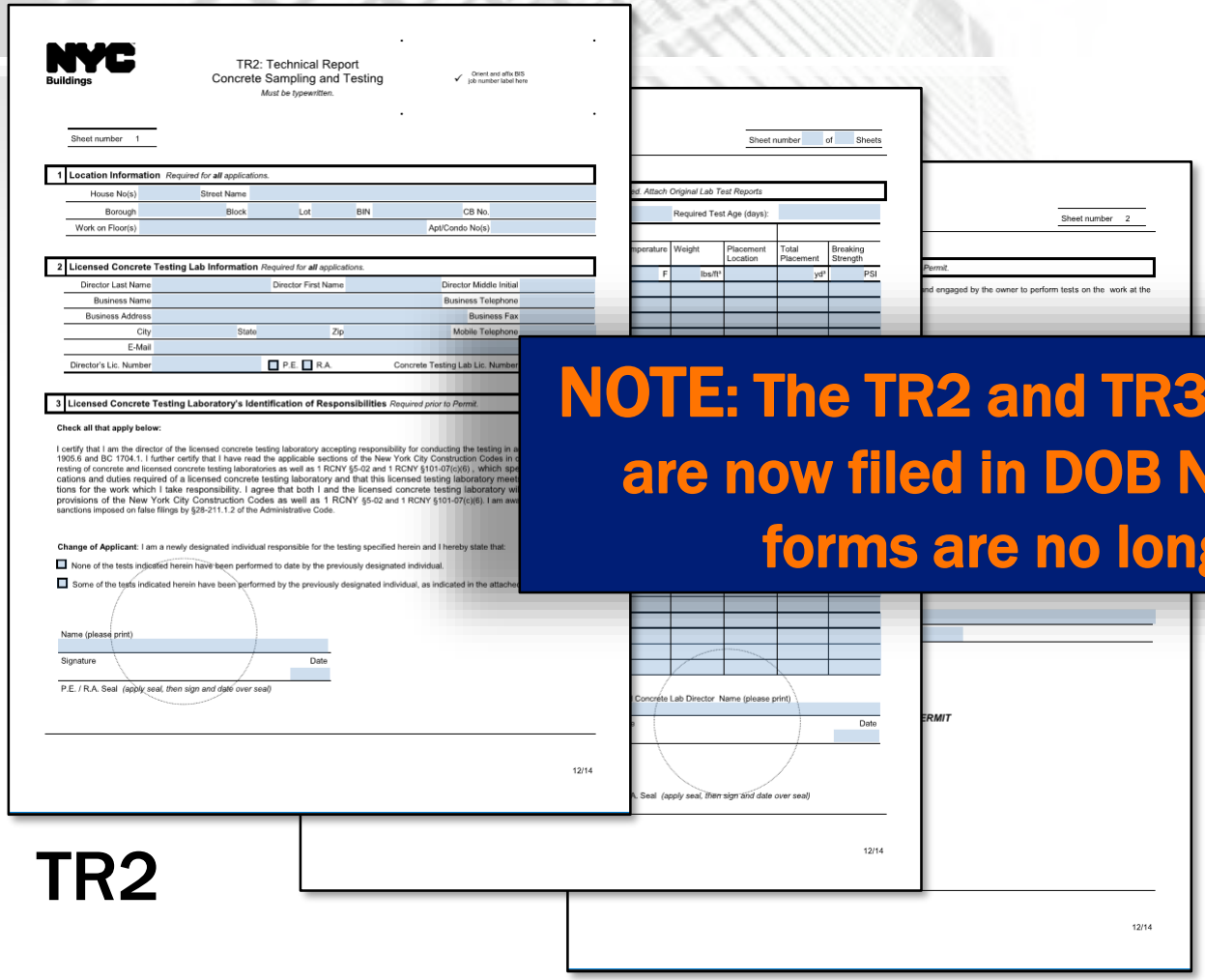
- **Legislative Responsibilities**

Engineering Audits

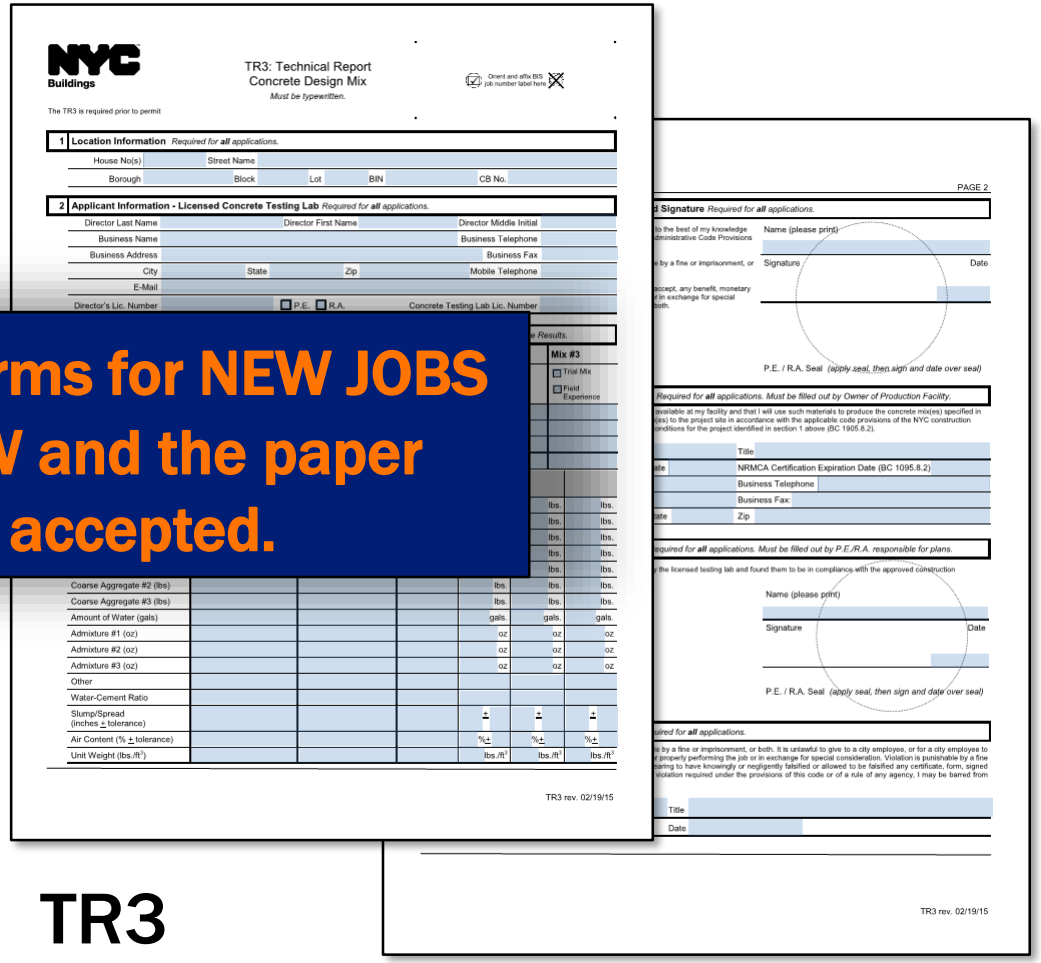
- Post-Permit Reviews *(continued)*
  - Concrete Operations/Construction
    - Checking TR2 and TR3 forms for all necessary items.
    - Checking Concrete Strength reports from licensed Concrete Testing Lab listed on TR2 form.
    - Checking Concrete Special Inspection reports for required information as per 1_RCNY 101-06 and ACI SP002-(11). Also ref ACI SP21PACK and ACI MNL-2(19)

- Incident Response
  - Formwork failures
  - Concrete Pump/Hose malfunctions
  - Concrete truck accidents

TR2 & TR3



TR2



TR3

NOTE: The TR2 and TR3 forms for NEW JOBS are now filed in DOB NOW and the paper forms are no longer accepted.

TR 2: CONCRETE POURING, SAMPLING & COMPRESSION TEST CYLINDERS

- Prior to permit, the Department requires a Concrete Test Cylinder Technical Report (TR2) to identify responsibilities for inspections. The TR2 identifies the lab that will be performing the concrete sampling and testing. This report is also required prior to sign off to certify completion of concrete pouring, sampling and compression test cylinders.
- A Department-licensed Concrete Testing Lab must submit the TR2, and the lab must attach the trial mixture reports and/or the field experiment results before permit issuance.

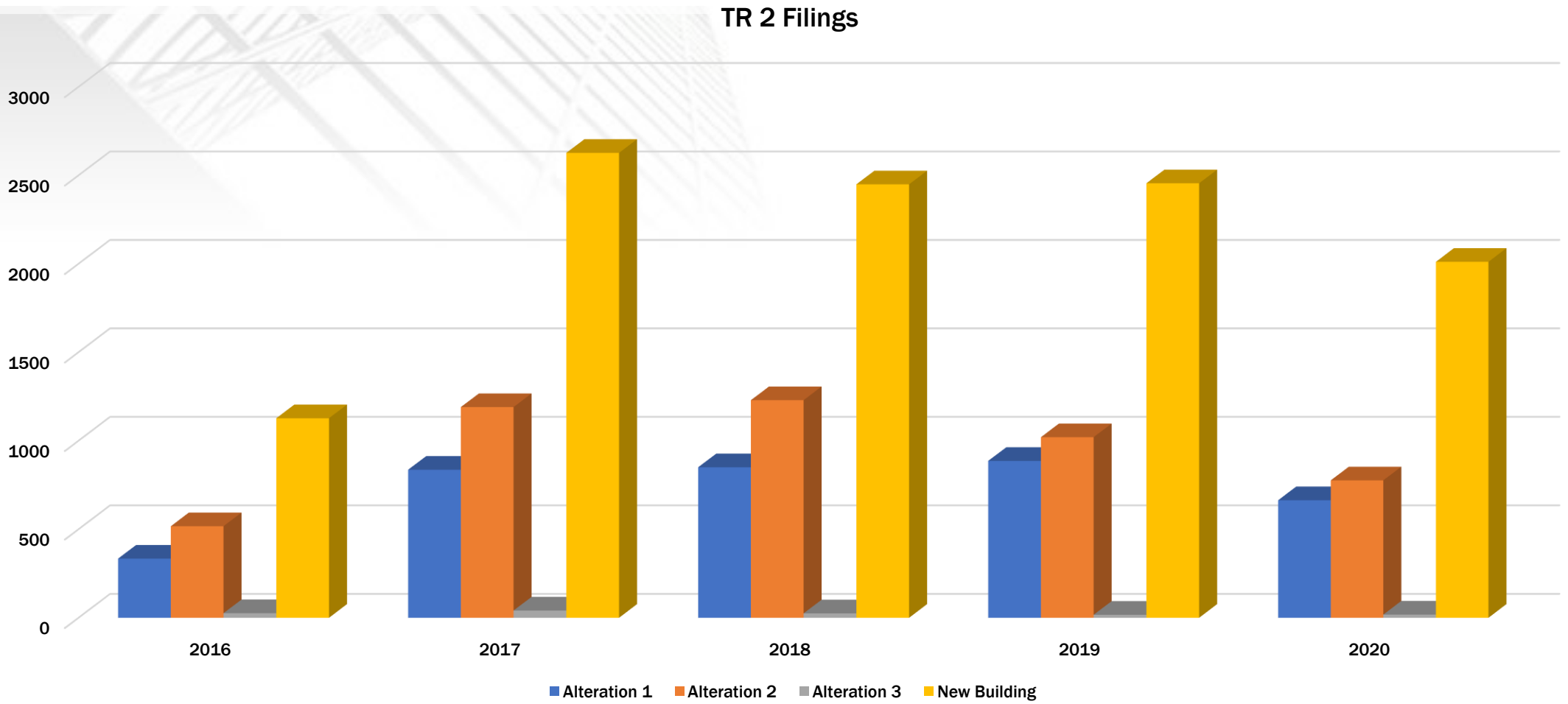
TR 2: CONCRETE POURING, SAMPLING & COMPRESSION TEST CYLINDERS

- The TR2 includes the following required sections:
  - Design Applicant Statement and signature in Identification of Responsibilities and Certification of Completion (required prior to permit and prior to sign-off);
  - Building Owner Statement and signature (required prior to permit); and
  - Concrete Producer's Statement and signature (required prior to sign-off).

RETESTING

- Retesting of concrete may be required due to low strength results or inaccuracies in field testing
- Engineer of record will be involved and required to provide interim report
- Engineer of record may need to submit a concrete retesting report
- Reference: Buildings Bulletin 2009-014

TR 2: CONCRETE POURING, SAMPLING & COMPRESSION TEST CYLINDERS



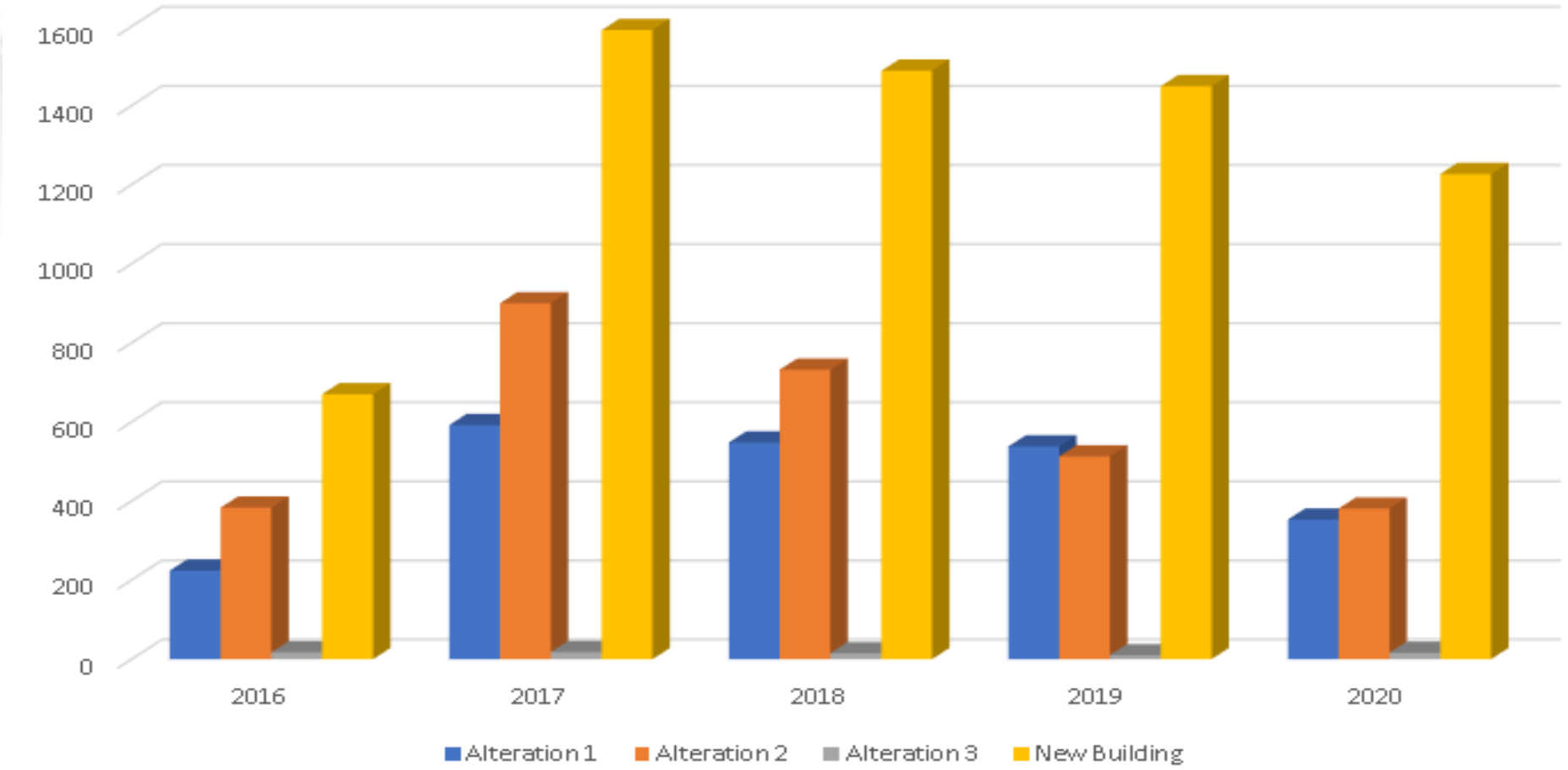
TR 3: CONCRETE MIX DESIGN

- Prior to permit on all jobs in which concrete will be used, the Department requires a Concrete Design Mix Technical Report (TR3). Filing of the TR3 identifies the concrete mixes to be used on the job site. This must be done before permit issuance.
- A Department-licensed Concrete Testing Lab must submit the TR3 , and the lab must attach the trial mixture reports and/or the field experiment results

OBTAINING CONCRETE MIX INFORMATION

- The concrete mix information is provided by the concrete testing laboratory that designed the mix.
- These forms capture information about the strength of the concrete mix to be used and the lab performing the concrete testing. It is important that the Department have this information on file **before permits are issued** and concrete is poured

TR 3: CONCRETE MIX DESIGN FILINGS



PRE & POST PERMIT REQUIREMENTS FOR TR2 AND TR3

- The initial TR2 and the TR3 must be submitted prior to obtaining the permit. The final TR2 must be submitted prior to sign-off.

WHO IS RESPONSIBLE FOR THE TR2 & TR3?

- The TR2 and TR3 must be signed by two separate licensed concrete testing laboratories, each certified and qualified to provide the service. The same laboratory that designed the mix (TR3) cannot perform the field testing (TR2).
- Reference: Buildings Bulletin 2009-26

WHEN ARE THE TR2 & TR3 REQUIRED?

- Per New York City Building Code Table 1704.4, the TR2 and TR3 is required for all projects unless the following criteria are **all** met:
  - The total structural concrete specified for the project is less than 50 cubic yards ($38m^3$)
  - The structural design of the concrete is based on a specified compressive strength, no greater than 2,500 pounds per square inch (psi) (17.2 MPa), regardless of the compressive strength specified in the construction documents or used in the construction and
  - The concrete to be placed is specified to have a compressive strength of at least 4,000 psi (28 MPa); and
  - The design applicant elects to waive the testing requirements.

CONCRETE FORMWORK

CONRETE FORMWORK: DESIGN TRIGGERS

- **3305.3.1.3 Bracing.** Forms shall be properly braced or tied together so as to maintain position and shape, and shall conform to the sizes and shapes of members as shown on the **design drawings**.

- **3305.3.2.1 Design drawings.** Site-specific formwork design drawings prepared by a registered design professional shall be required in the following cases:
  1. For concrete formwork in a structure classified as a major building; or
  2. Wherever the shore or form height exceeds 14 feet (4267 mm); or
  3. Wherever the total vertical load on the forms exceeds 150 pounds per square foot (732 kg/m^2); or
  4. Wherever power buggies are used; or
  5. Wherever multi-stage shores are used; or
  6. Wherever the slab thicknesses or beam heights equal or exceed 10 inches; or
  7. Wherever there are concentrated loads exceeding 2000 pounds imposed on the formwork; or
  8. Wherever there are loads imposed on existing structures in accordance with Section 3305.3.1.2.1.

CONCRETE FORMWORK DESIGN DRAWINGS: EXCEPTION

- **Exception:** Design drawings prepared by a registered design professional are not required for formwork installed in conjunction with slabs supported directly on grade or footings where such slab or footing does not impart any load on an adjacent structure.

2014 NYC BUILDING CODE: CONCRETE FORMWORK

- **3305.3.1.1 Safe support of loads.** Formwork, including all related braces, shoring, framing, and auxiliary construction, shall be proportioned, erected, supported, braced, and maintained so that it will safely support all vertical and lateral loads that might be applied until such loads can be supported by the permanent construction.
- **3305.3.1.2 Vertical and lateral loads.** Vertical and lateral loads shall be carried to the ground by the formwork system, by the new construction after it has attained adequate strength for that purpose, or by existing structures. Forms and their supports shall be designed so as not to damage previously placed structures.

FORMWORK: SHORING FAILURE

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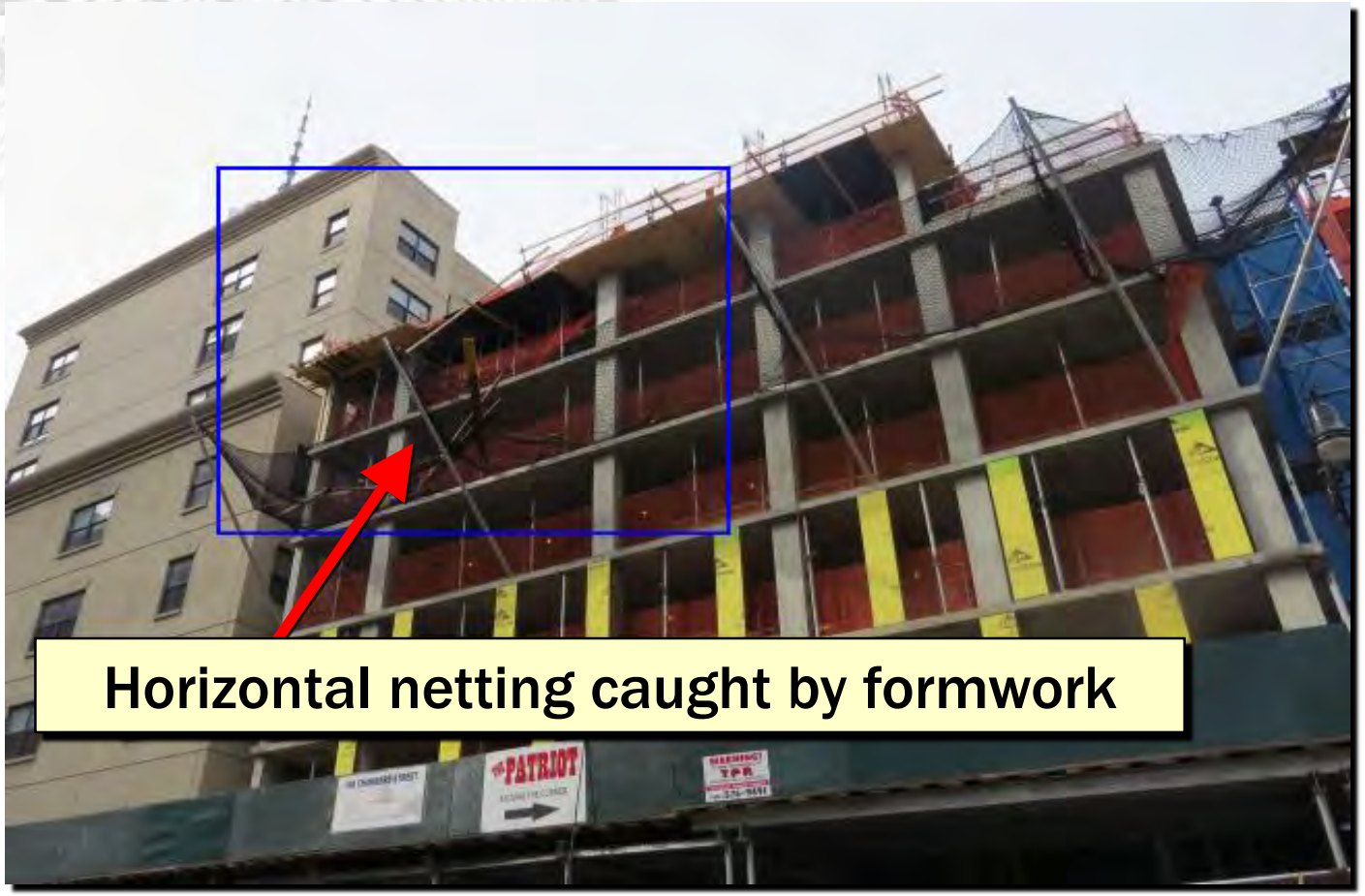

FORMWORK: SHORING FAILURE

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FORMWORK: SHORING FAILURE

LATERAL CONCRETE PRESSURE

- **3305.3.2.3 Lateral concrete pressure.** Design of forms, ties and bracing shall satisfy the minimum lateral pressures of fresh concrete specified in Table 3305.3.2.3.

LATERAL CONCRETE PRESSURE

TABLE 3305.3.2.3
MINIMUM LATERAL PRESSURES TO BE ASSUMED FOR FRESH CONCRETE WEIGHING 150 POUNDS PER CUBIC FOOT [a, b, c]

Type of Work	Minimum Lateral Pressure Assumed (psf)	Limitations
Columns: Ordinary work with normal internal vibration	$p = 150 + (9000R/T)$	Maximum 3,000 psf or $150h$, whichever is less
Walls: Rate of placement at 7 feet per hour or less	$p = 150 + (9000R/T)$	Maximum 2,000 psf or $150h$, whichever is less
Walls: Rate of placement at greater than 7 feet per hour	$p = 150 + (43400/T) + (2800R/T)$	Maximum 2,000 psf or $150h$, whichever is less
Slabs	$p = 150h$	None

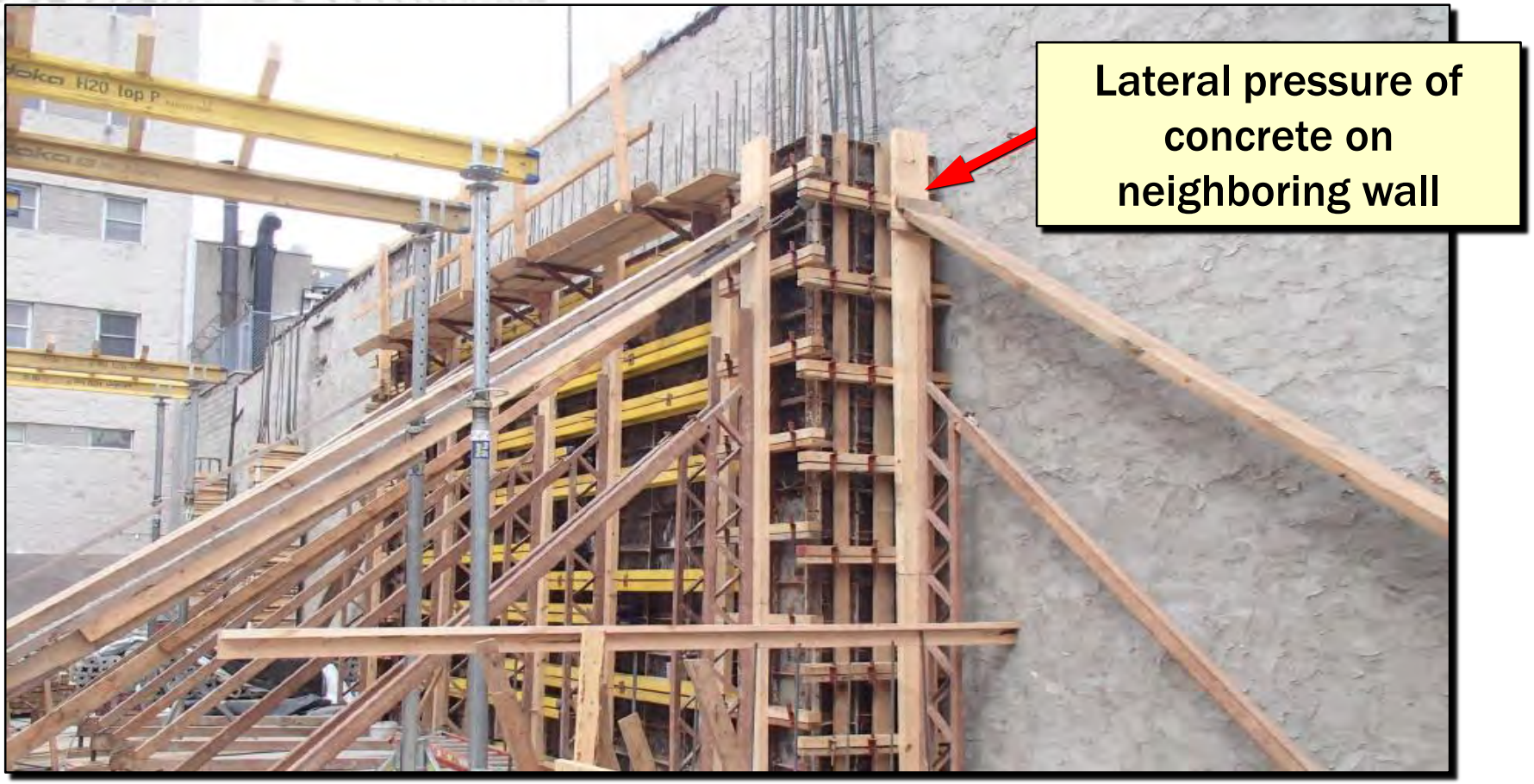
For SI: 1 inch = 25.4 mm, 1 foot per second = 0.305 m/s, 1 pound per cubic foot = 16.02 kg/m^3, 1 pound per square foot = 4.882 kg/m^2, °C = (°F-32)/1.8.

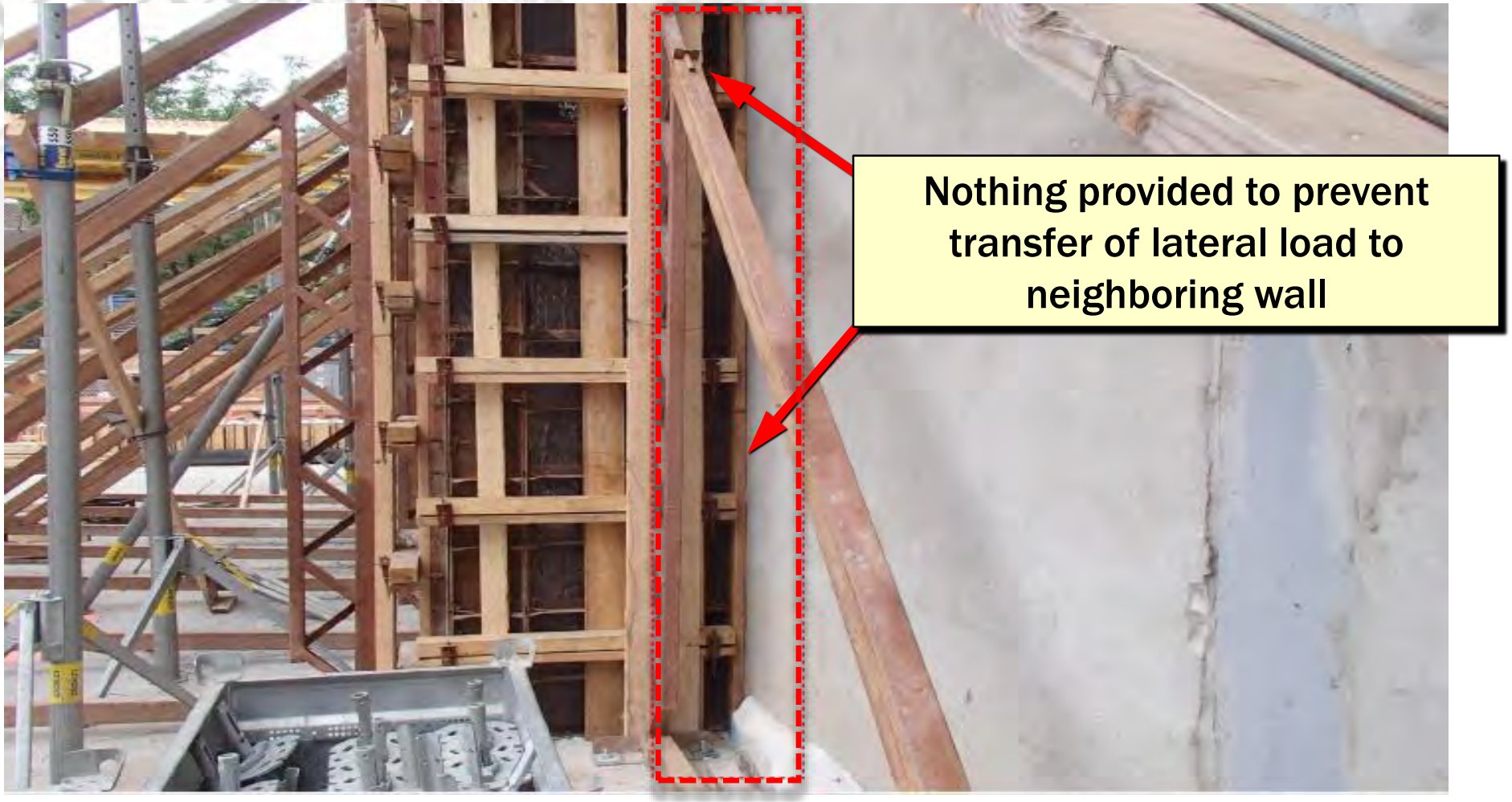
where:

R = rate of placement, feet per hour.
T = temperature of concrete in the forms, °F.
h = height of fresh concrete above point considered, feet.

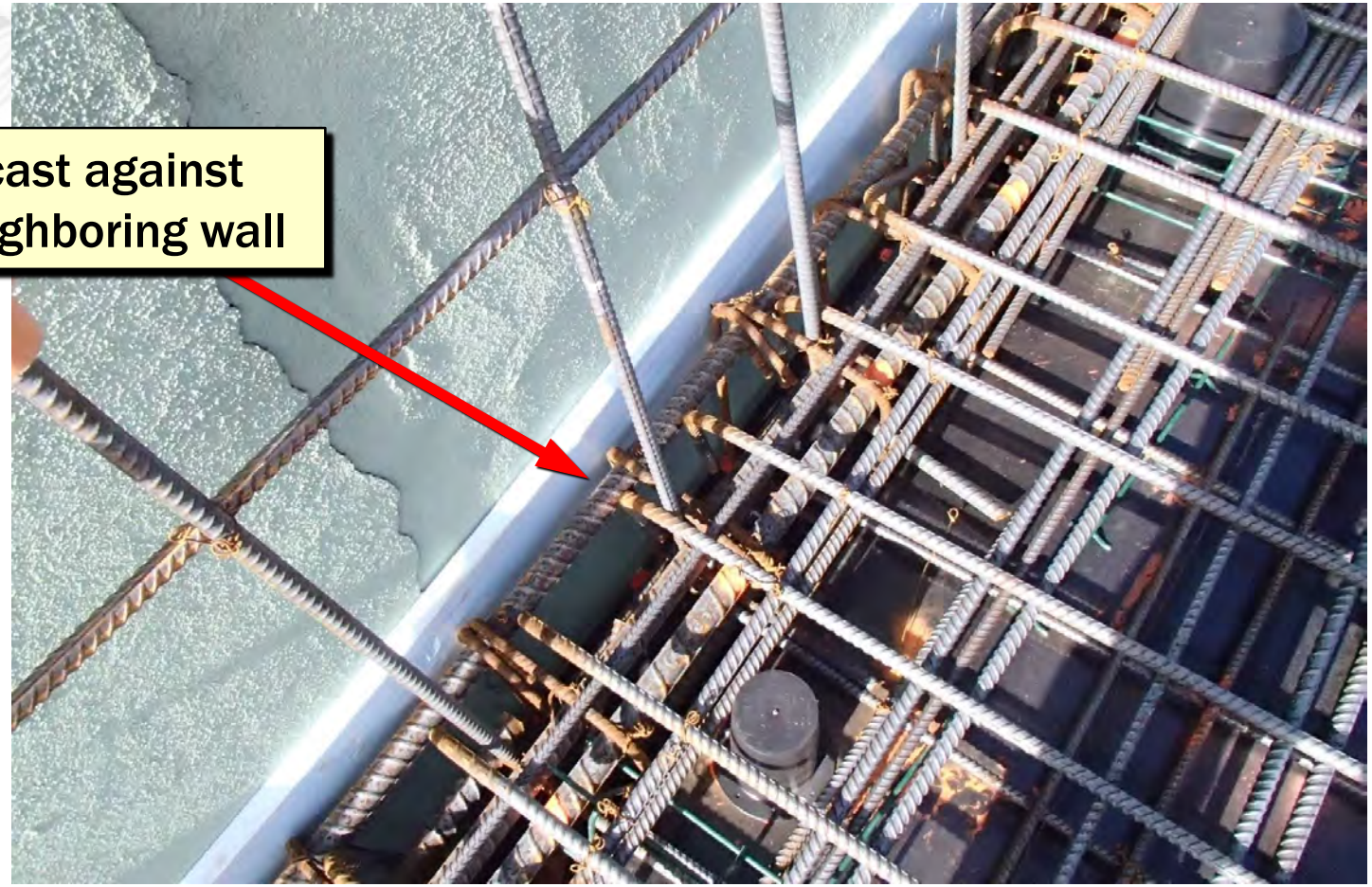
a. Allowances for change in lateral pressure shall be made for concrete weighing other than 150 pcf, for concrete containing pozzolanic additions or cements other than Type I, for concrete having slumps greater than 6 inches, or for concrete consolidated by revibration or external vibration of forms.
b. Where retarding admixtures are employed under hot weather conditions, an effective value of temperature less than that of the concrete in the forms shall be used in the above formula.
c. If retarding admixtures are used in cold weather, the lateral pressure may be assumed as that exerted by a fluid weighing 150 pcf.

FORMWORK FAILURE: DAMAGE TO ADJACENT PROPERTY

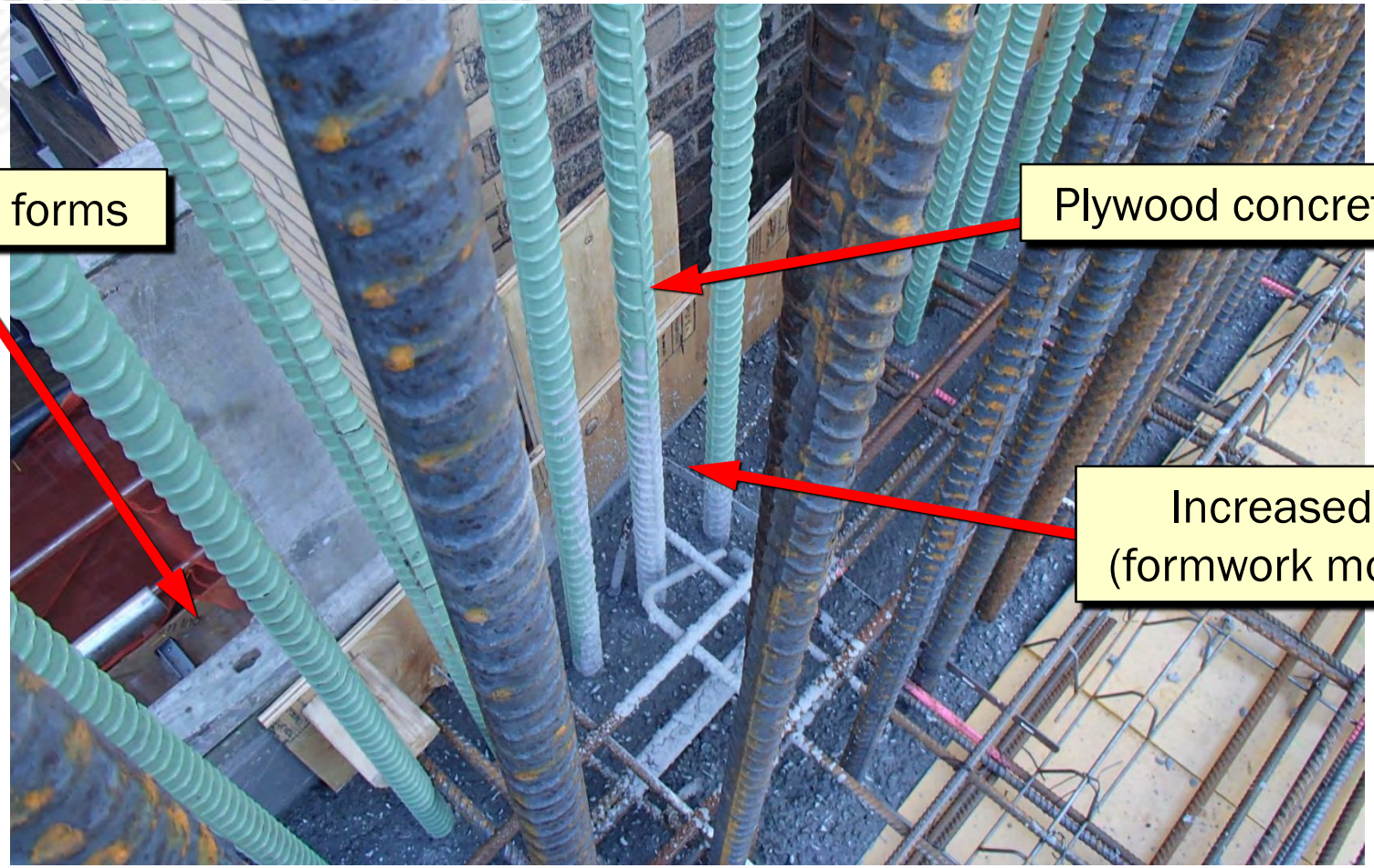

H20 top P
Lateral pressure of concrete on neighboring wall


Nothing provided to prevent transfer of lateral load to neighboring wall

IMPROPER FORMWORK: ADJACENT STRUCTURE



FORMWORK: IMPROPER CHANGE IN FORMWORK SYSTEM



IMPROPER USE OF STAY IN PLACE FORMS: LEAKAGE

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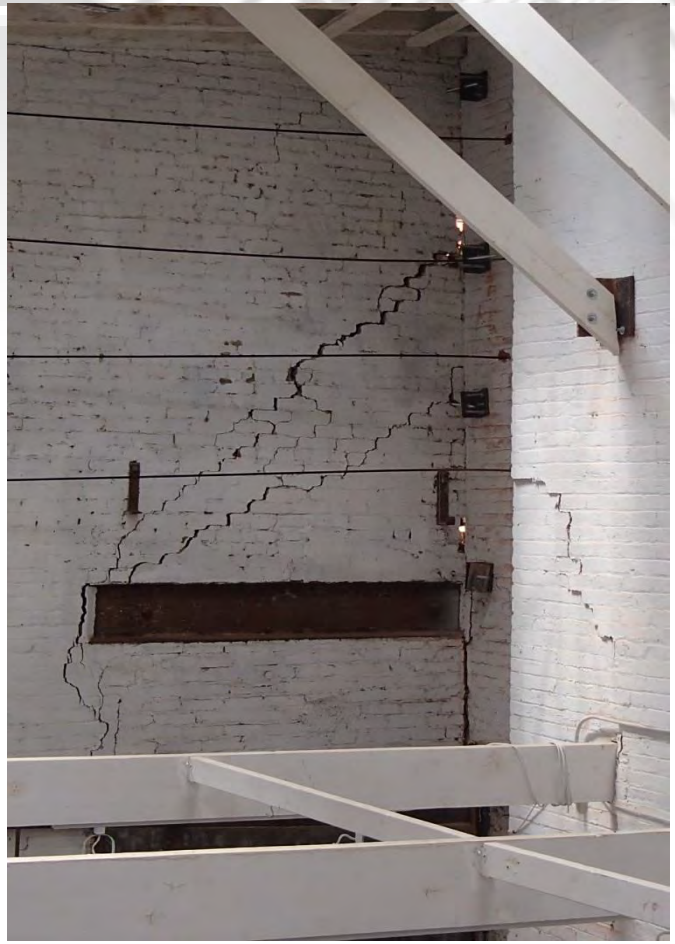
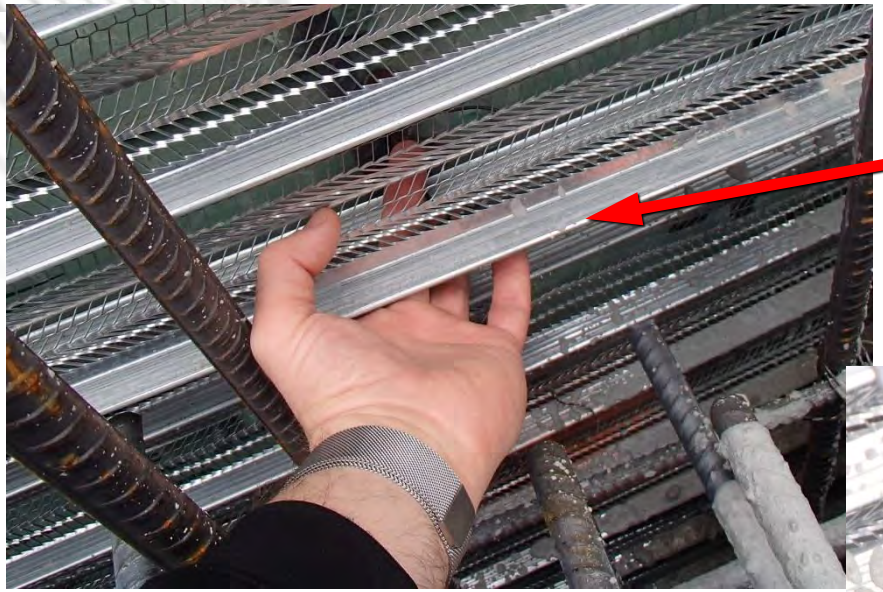
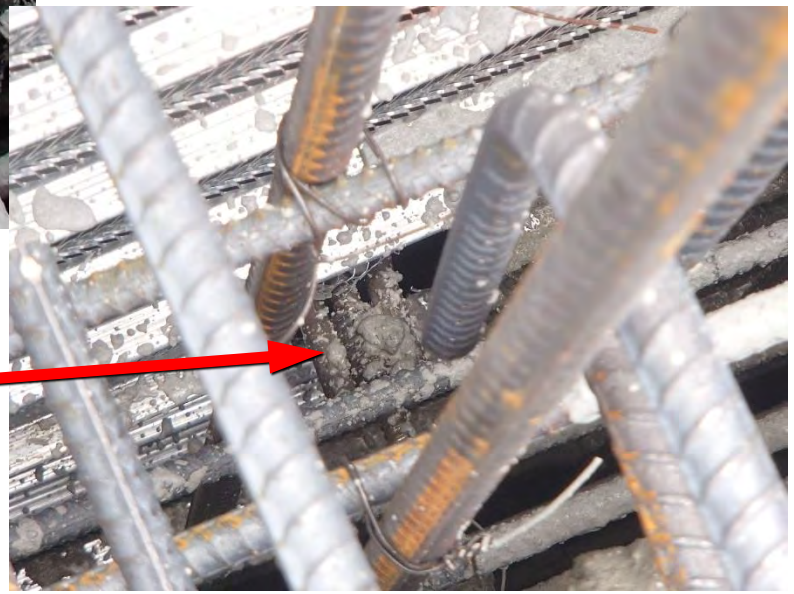


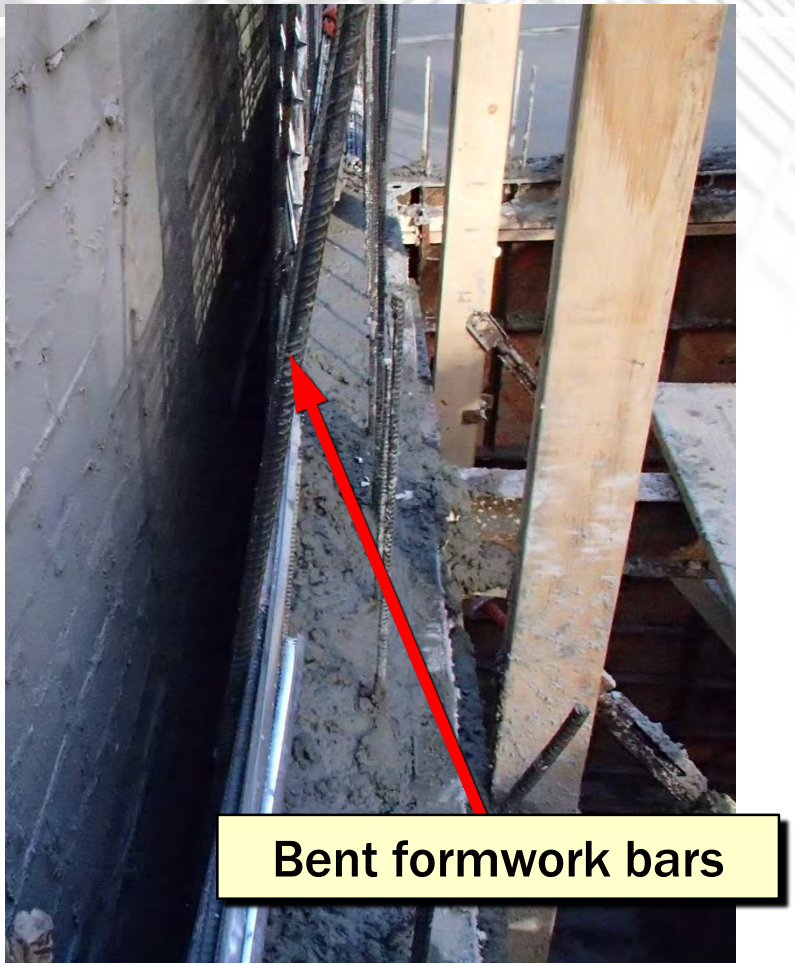


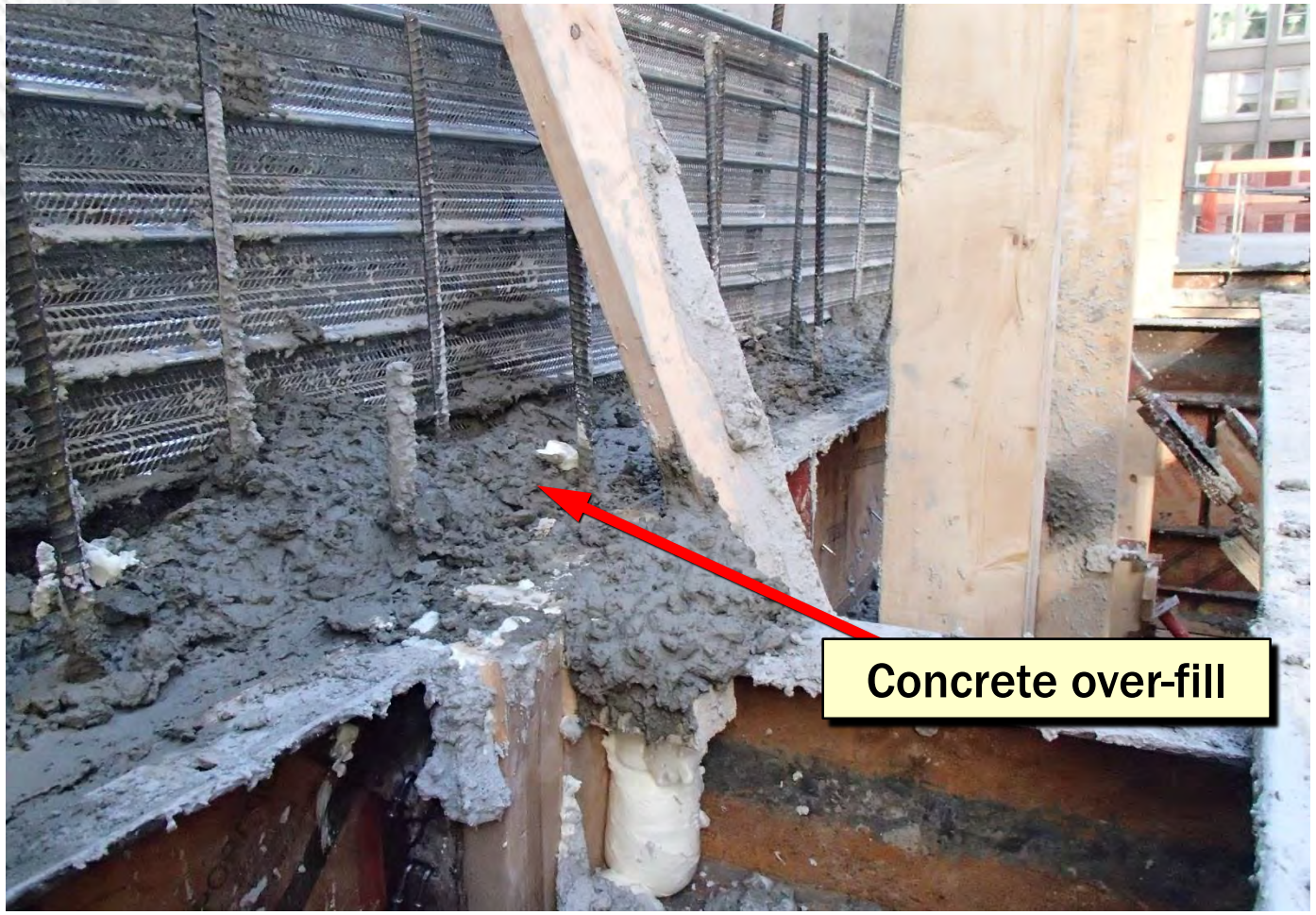
Improperly lapped mesh (gaps/overlap)

Holes for tie rods too large to retain concrete



IMPROPER USE OF STAY IN PLACE FORMS: LEAKAGE



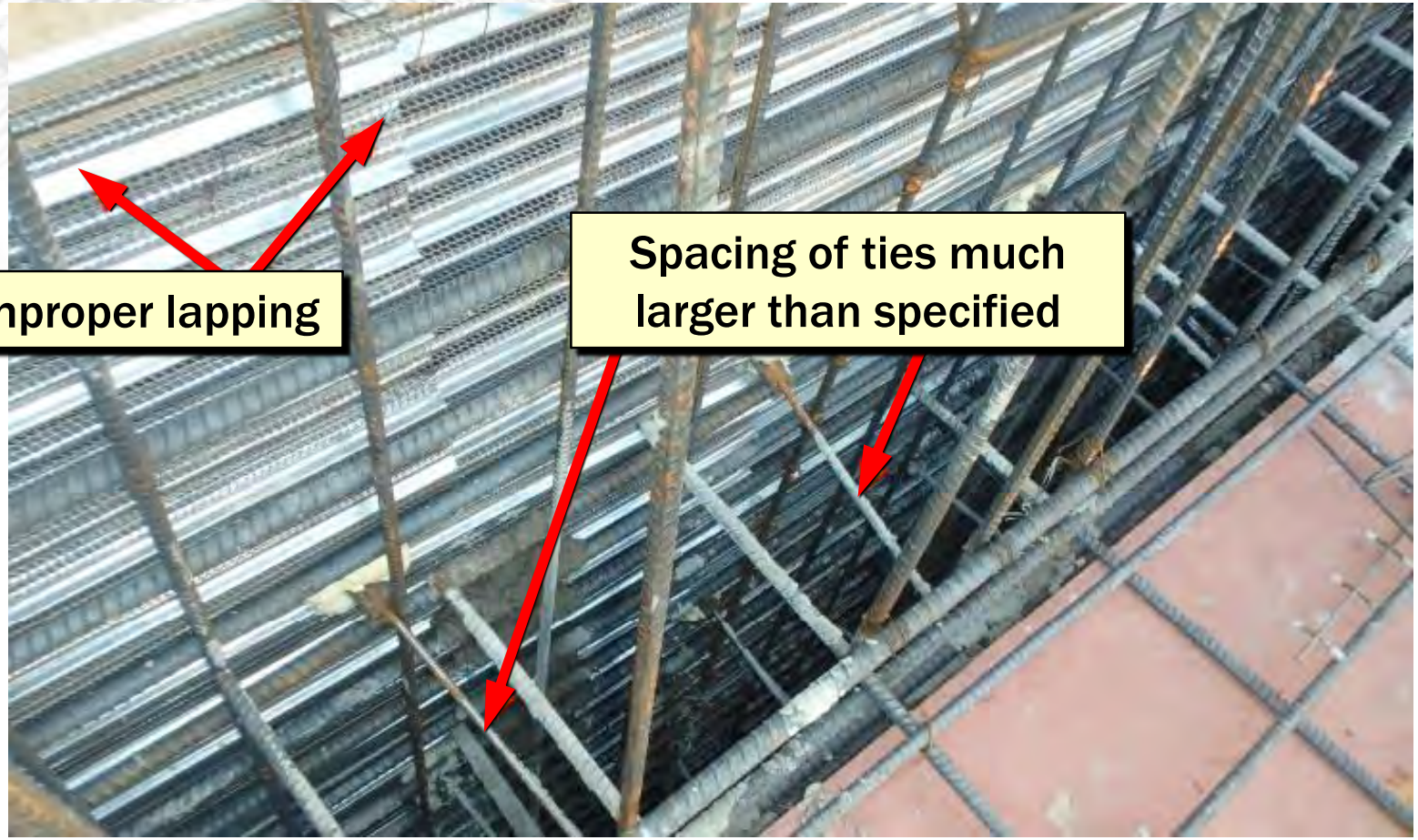


IMPROPER USE OF STAY IN PLACE FORMS: FAILURE

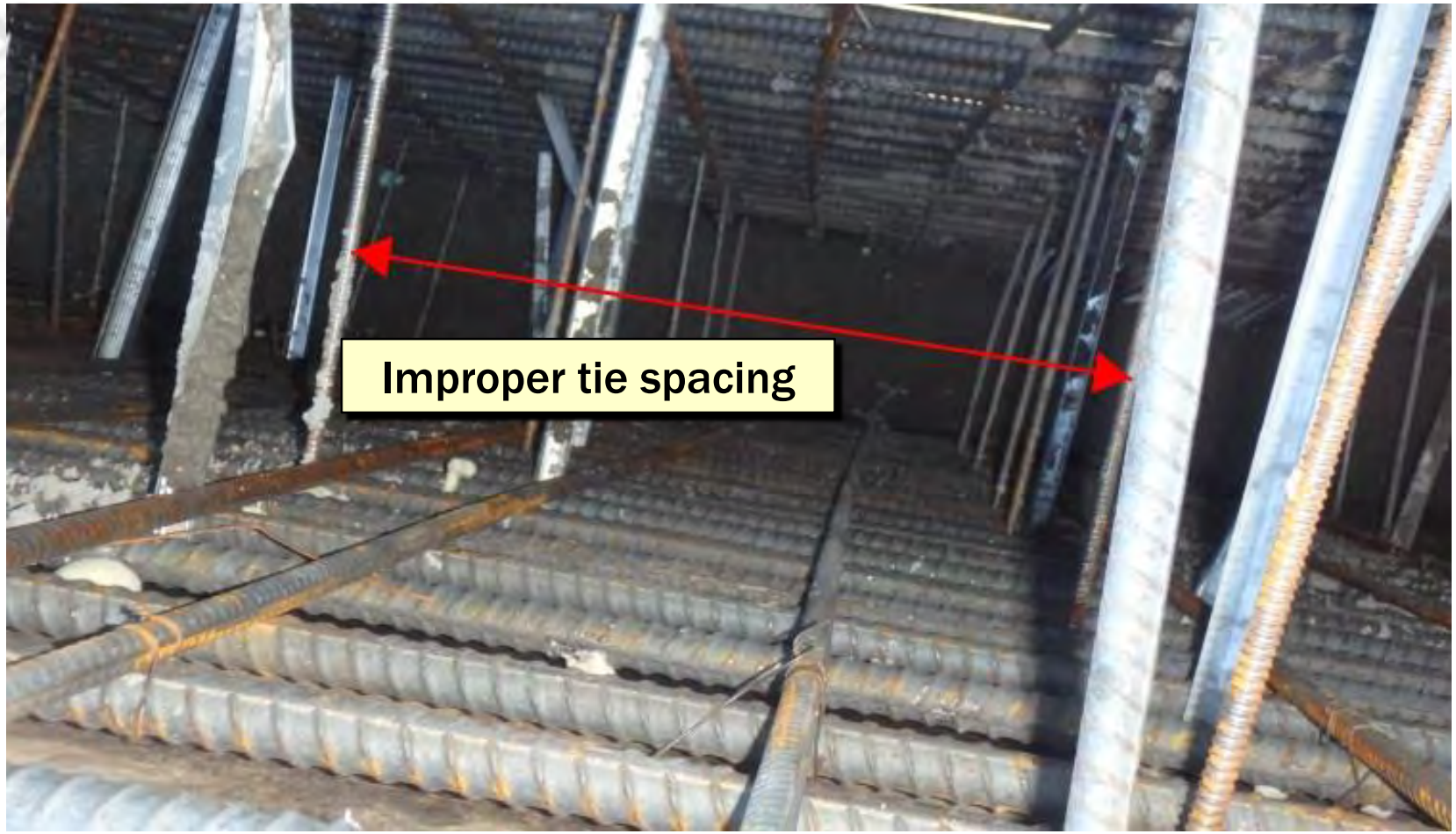
IMPROPER USE OF STAY IN PLACE FORMS: BENDING

FORMWORK: STAY IN PLACE FORMS

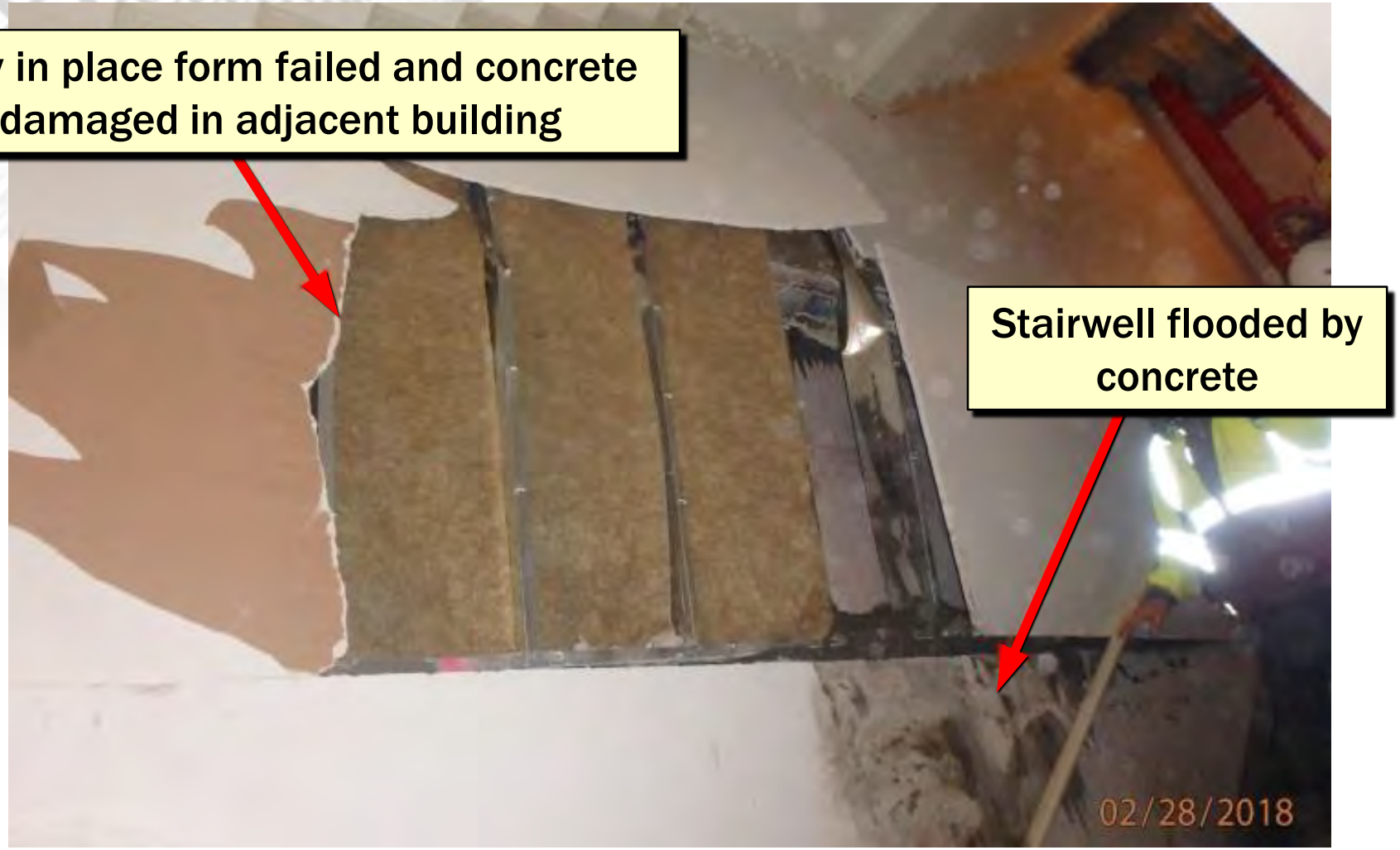
FORMWORK: STAY IN PLACE FORMS



FORMWORK:
STAY IN PLACE FORMS – SPACING OF TIES

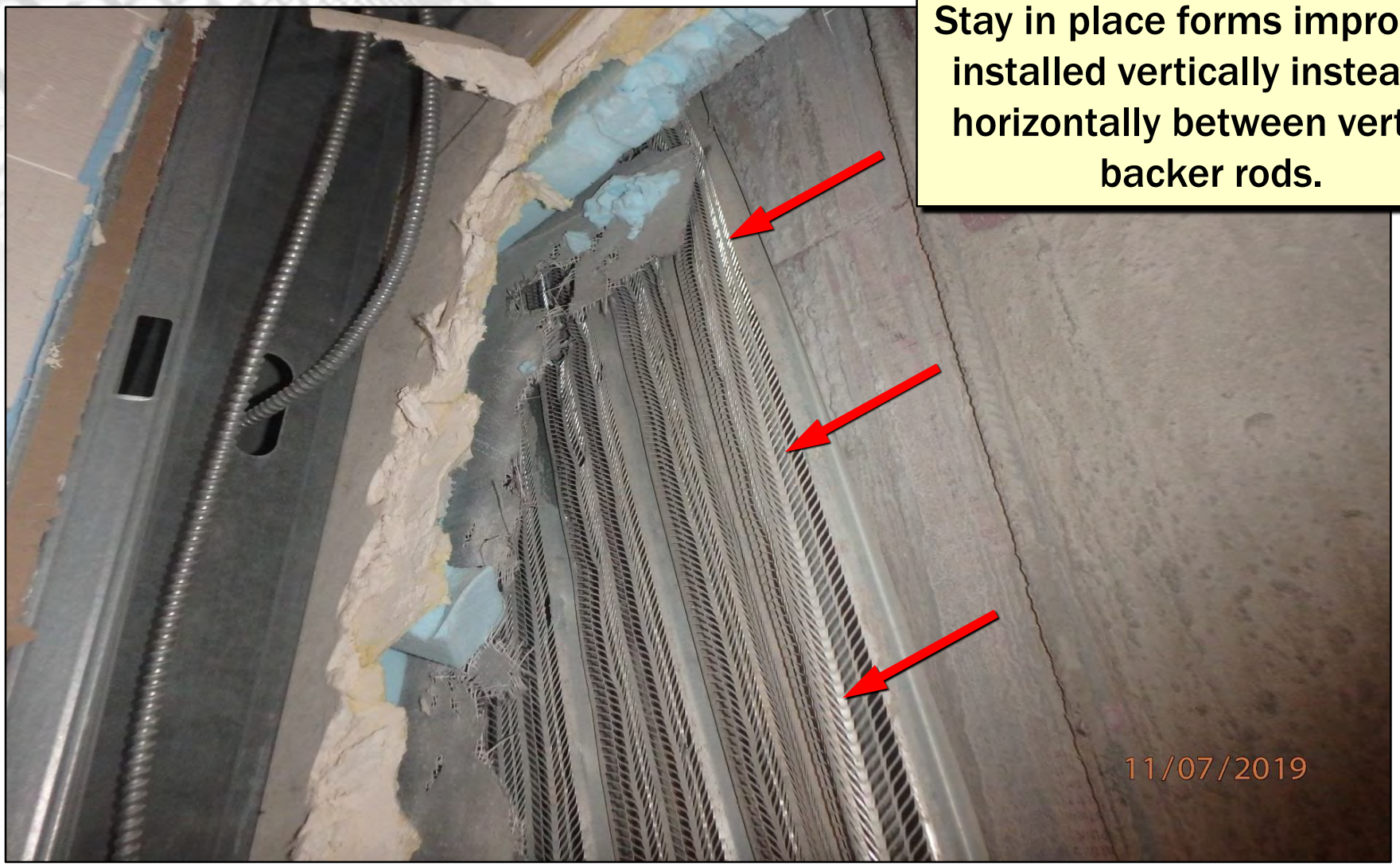


FORMWORK: STAY IN PLACE FORMS



FORMWORK: STAY IN PLACE FORMS

Improperly installed stay in place forms failed, damaging adjacent property. Entire room flooded with concrete.



Stay in place forms improperly installed vertically instead of horizontally between vertical backer rods.

2014 NYC BUILDING CODE: CONCRETE FORMWORK

- **3305.3.1.2.1 Use of existing structures to support vertical or lateral loads.** The use of existing structures to support vertical or lateral loads imposed by concrete construction operations shall require an evaluation of the existing structure for the loads imposed by a registered design professional. The registered design professional shall prepare design drawings documenting the findings of the evaluation, indicate the location of formwork elements, and the interface between the formwork and the existing structure.

RESHORING

- **3305.3.6.8 Reshoring schedule.** A signed and sealed reshoring schedule shall be provided and maintained at the construction site whenever reshoring is employed.

- **Exception:** A separate reshoring schedule is not required when the required reshoring information is covered on the approved construction documents prepared by the applicant of record.

FORMWORK: INSPECTION REQUIREMENTS

- **3305.3.3.1 Inspection.** Formwork, including shores, reshores, braces and other supports, shall be inspected prior to placement of reinforcing steel to verify that they conform to the construction documents and form design drawings. Such inspections shall be performed by a qualified person designated by the contractor; nothing shall prohibit the concrete safety manager from performing such inspection where so designated. Subsequently, inspections shall be performed by such person periodically during the placement of concrete. During and after concreting, the elevations, camber, and vertical alignment of formwork systems shall be inspected using tell-tale devices. A record of all such inspections shall be kept at the site available to the commissioner. The names of the persons responsible for such inspections and the foreman in charge of the formwork shall be posted in the field office.

FORMWORK: OBSERVATION REQUIREMENTS

- **3305.3.3.2 Formwork observation.** In addition to the inspections by the contractor required pursuant to Section 3305.3.3.1, visual observations of the formwork for the general conformance with the design intent shall be performed by:

  1. The formwork designer;

  2. An employee of the formwork designer under his or her direct supervision;

  3. A registered design professional retained by the formwork designer; or

  4. An employee of such retained registered design professional under the direct supervision of such retained registered design professional.

FORMWORK: OBSERVATION EXCEPTIONS

- **Exceptions:** Formwork observation pursuant to Section 3305.3.3.2 shall not be required for:
  1. Formwork that does not require design drawings pursuant to Section 3305.3.2.1; and
  2. One, two, and three-family dwellings and accessory uses to such buildings.

CONCRETE SAFETY MANAGERS

- Major building + 2,000 cubic yards = CSM REQUIRED
- NYC BC 3310.9.1
- The concrete safety manager shall be present during all concrete operations.
- Concrete operations = the pouring of concrete and the construction and stripping of concrete forms and related activities as specified by the commissioner
- **Exception:** A concrete safety manager need not be present for concrete operations involving exclusively sidewalks, driveways, mechanical pads or other miscellaneous areas.

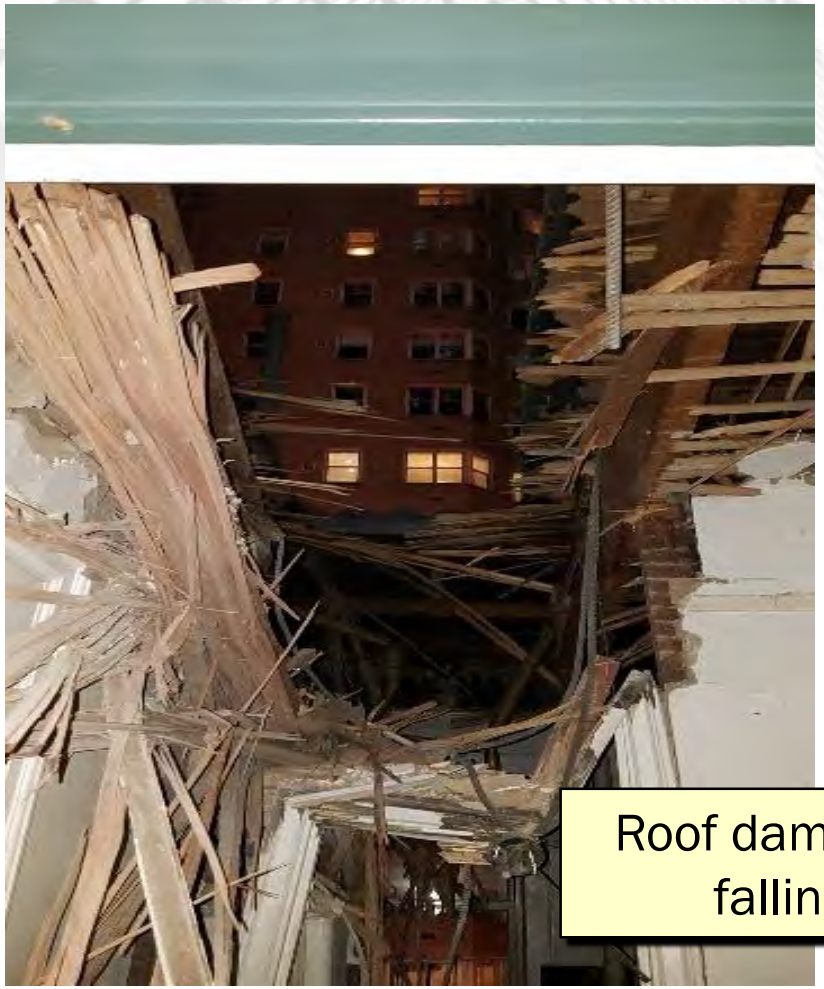
CONCRETE SAFETY MANAGER DUTIES

- Reference: 1RCNY 3310-02
- Must be onsite and available during all concrete operations and until the removal of the reshores and horizontal safety netting is completed
- Must be registered on the PW2 form
- CSM is integral in protecting against falls, falling concrete and objects, collapsing floors and similar dangers in relation to concrete, formwork, shoring, reinforcement steel.
- As an extension of the DOB, CSM must report all accidents outlined in 1RCNY 3310-02

CONCRETE SAFETY MANAGER LOG BOOK

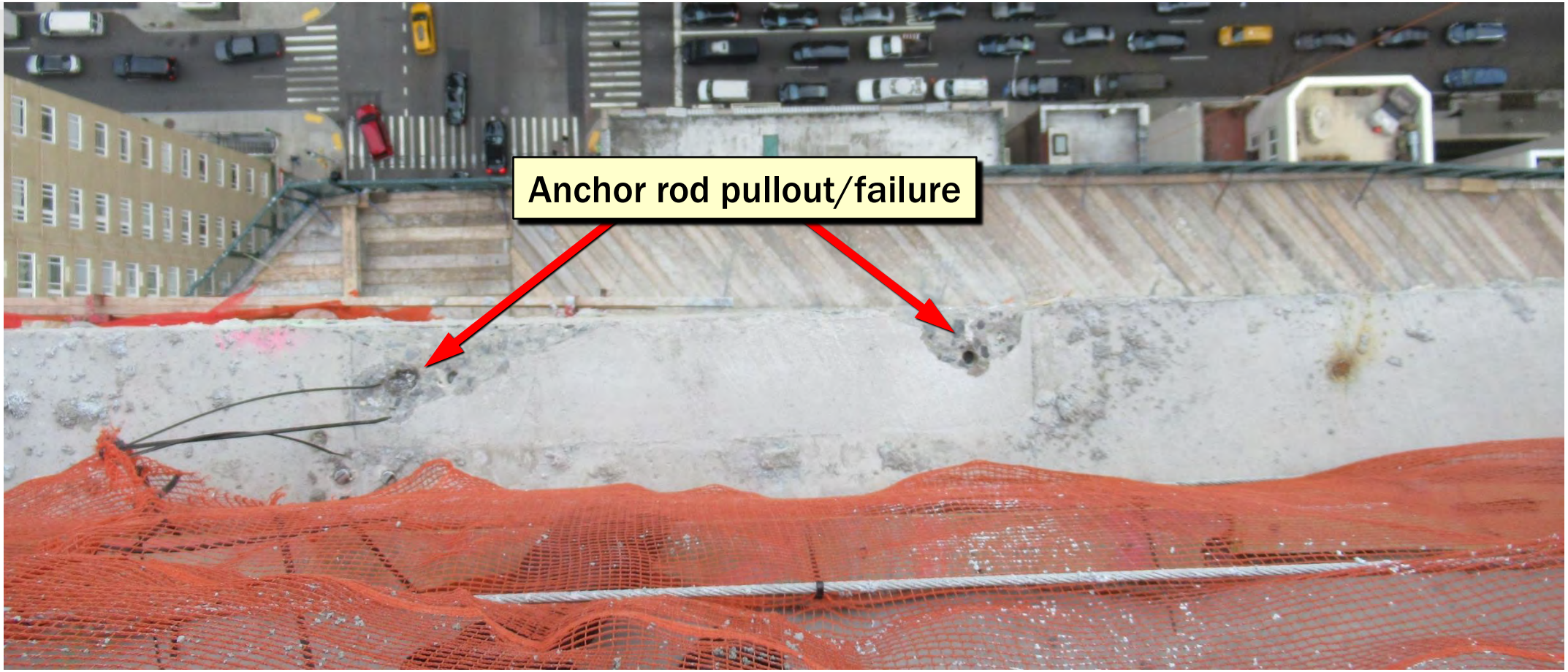
- CSM must keep a daily log of all concrete operations pertaining to the job site as outlined in 1RCNY 3310-02
- CSM checklist is available on the Concrete Safety Managers page on the buildings website. The checklist is for reference only
- https://www1.nyc.gov/site/buildings/industry/concrete-safety-managers.page

MASONRY: IMPROPER SHORING, ANCHORAGE & CONSTRUCTION



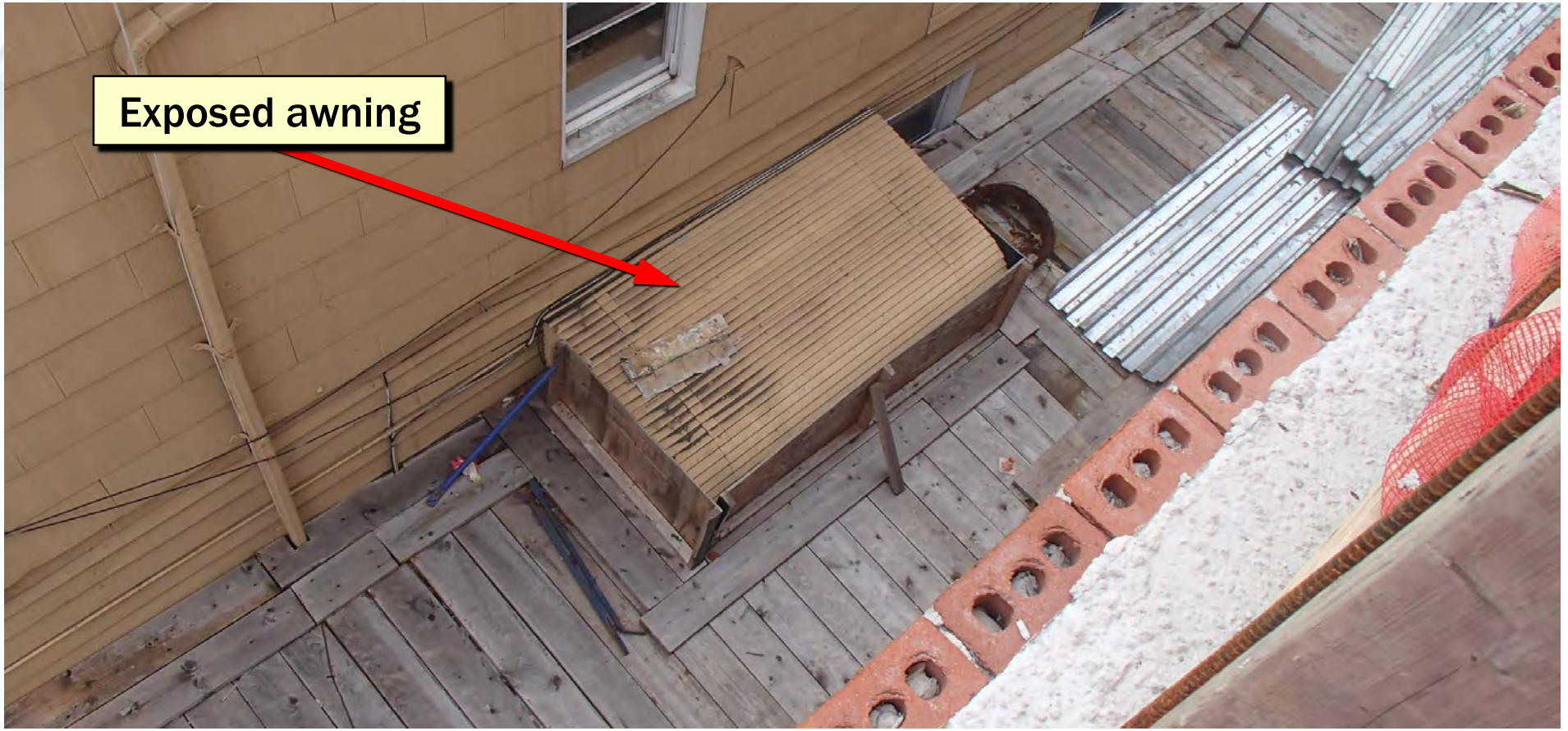
Roof damage due to falling CMU

MASONRY: IMPROPER SHORING, ANCHORAGE & CONSTRUCTION



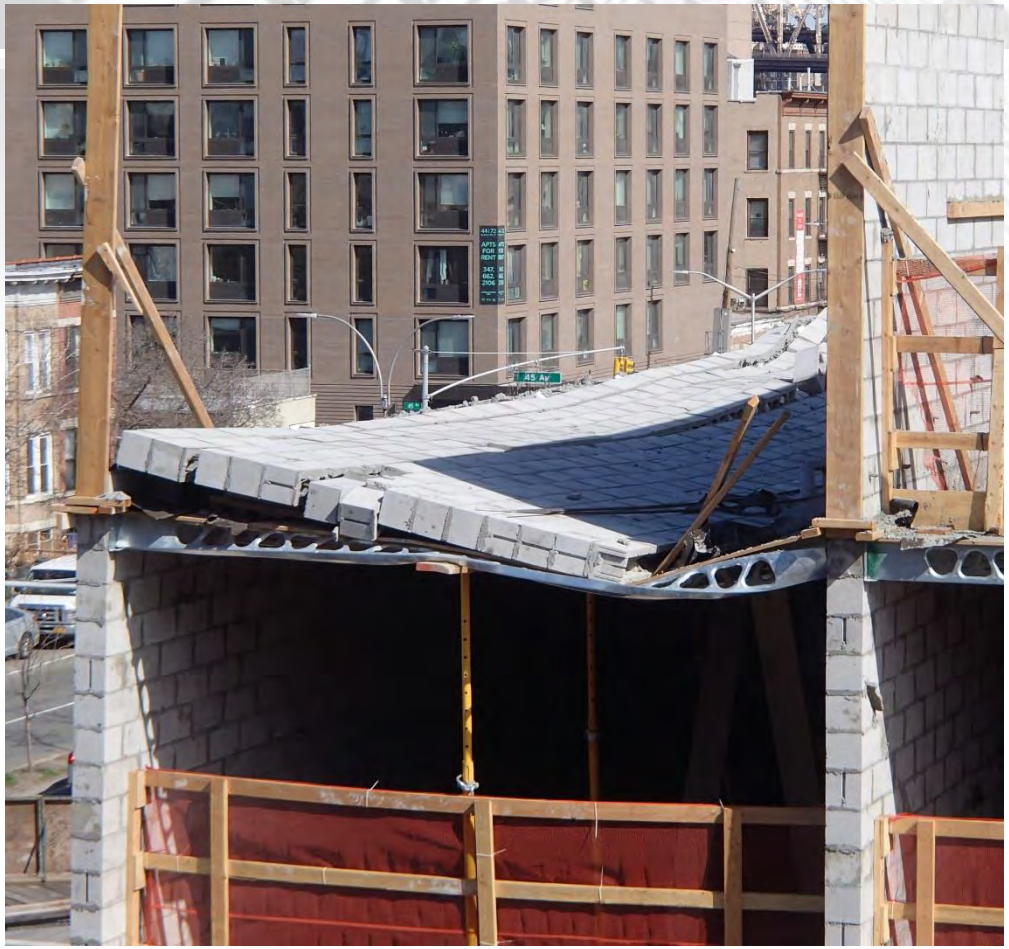
MASONRY: IMPROPER SHORING & CONSTRUCTION

IMPROPER PROTECTION



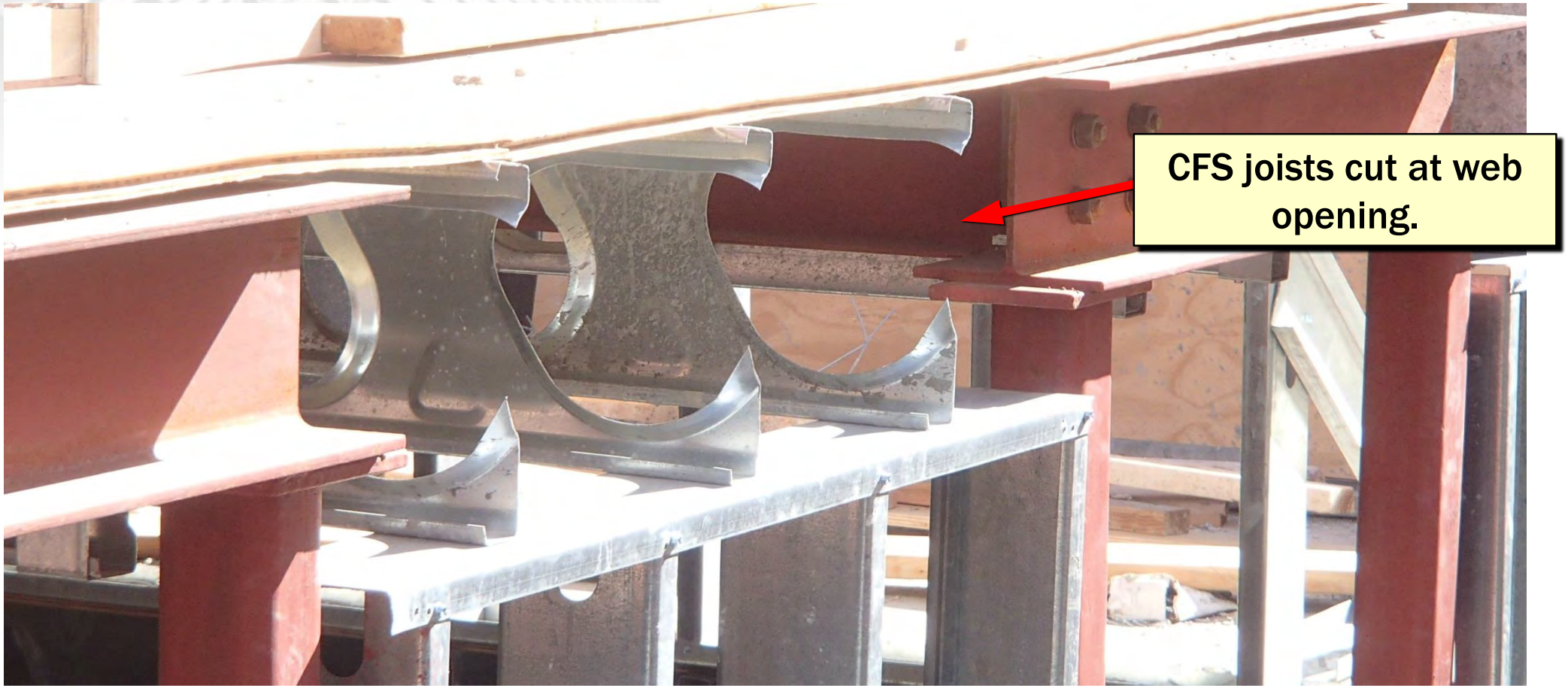
IMPROPER PROTECTION

MASONRY: IMPROPER SHORING & CONSTRUCTION

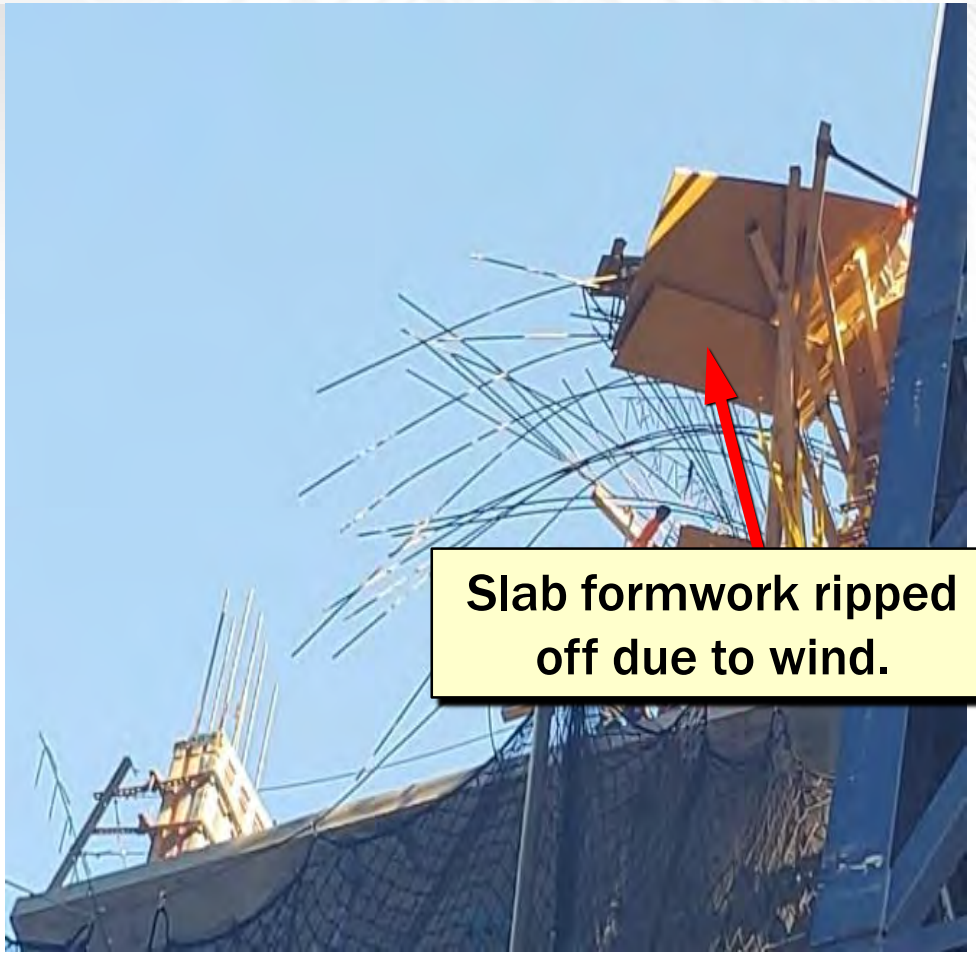


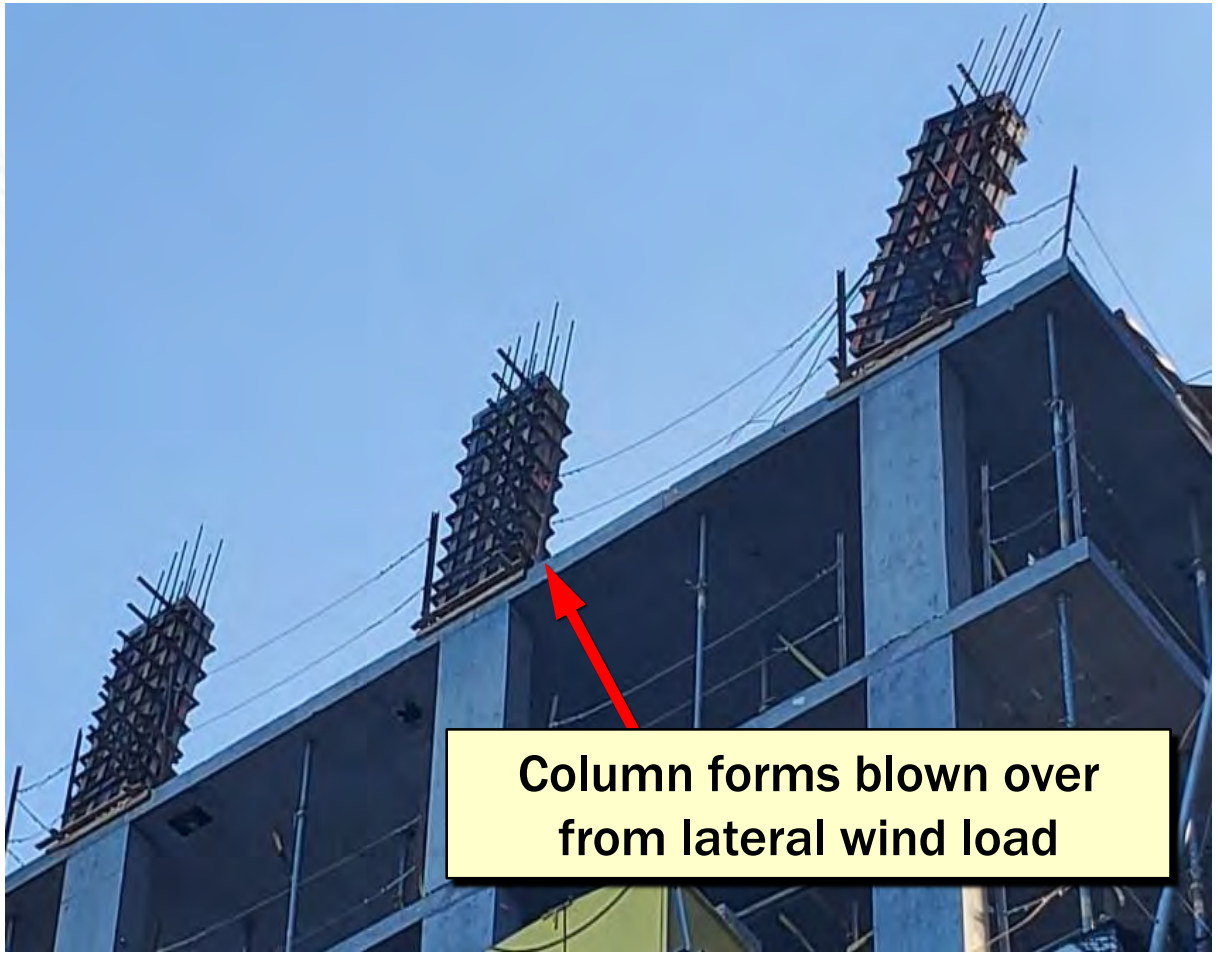
FORMWORK: NON DOCUMENTED

IMPROPER SHORING: SYMPTOM OF OTHER PROBLEMS

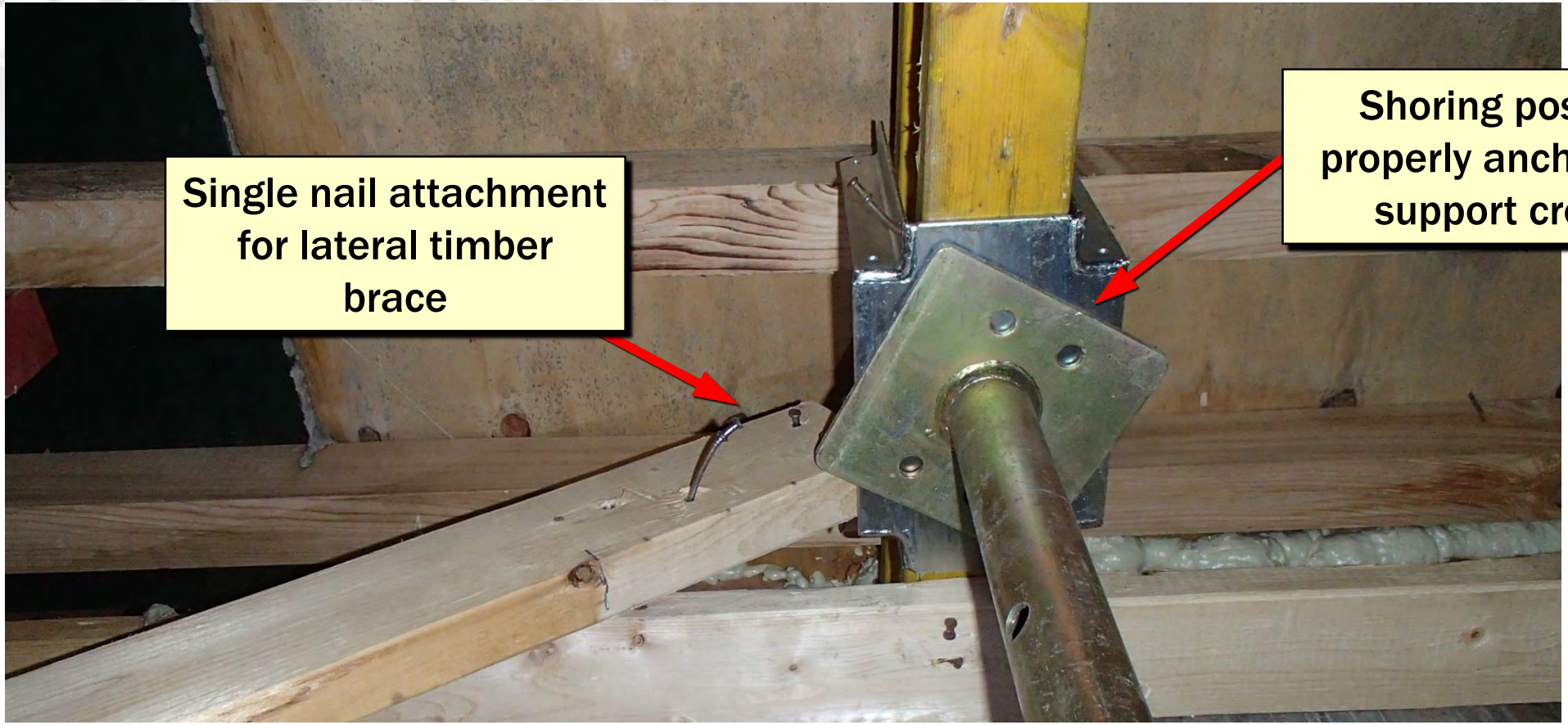


IMPROPER SECURING OF FORMS

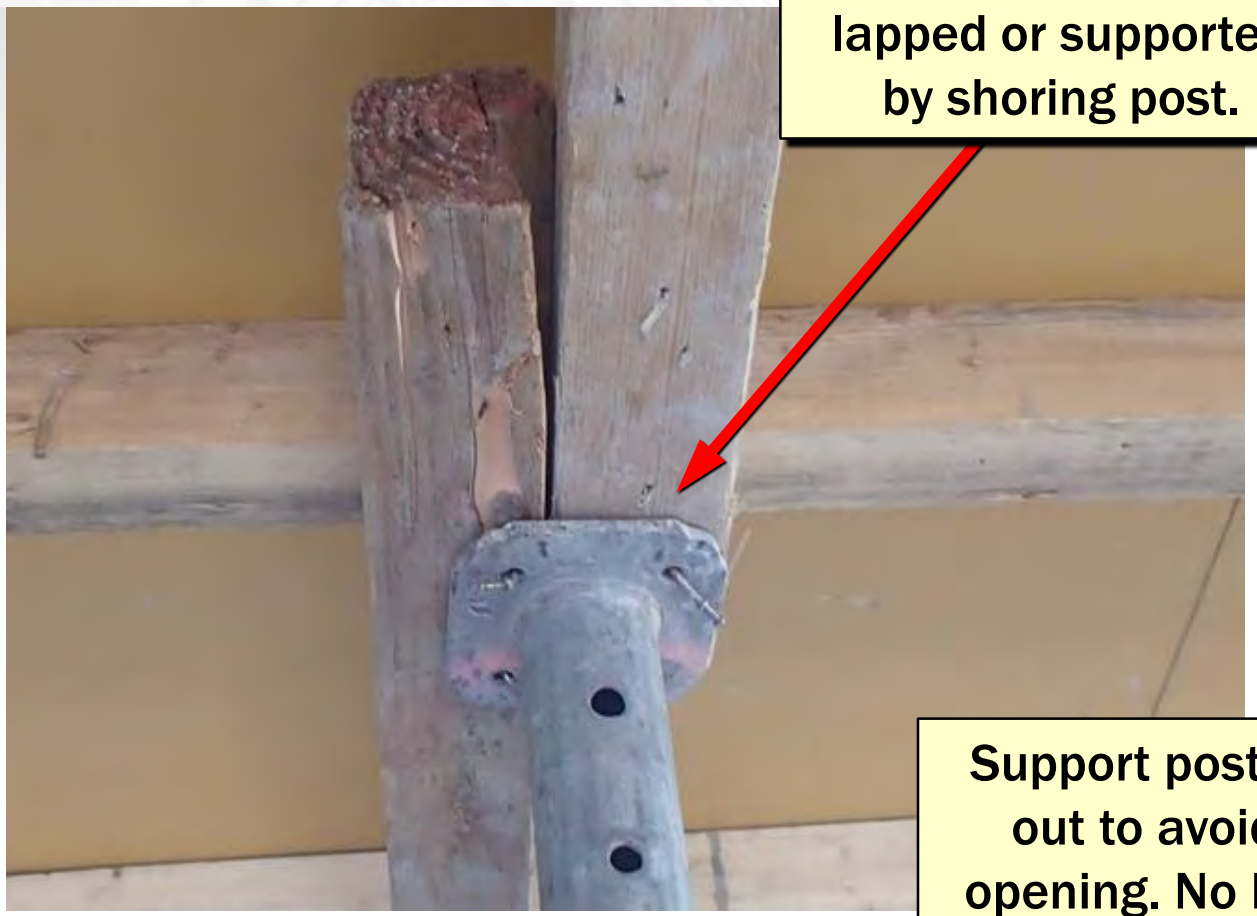




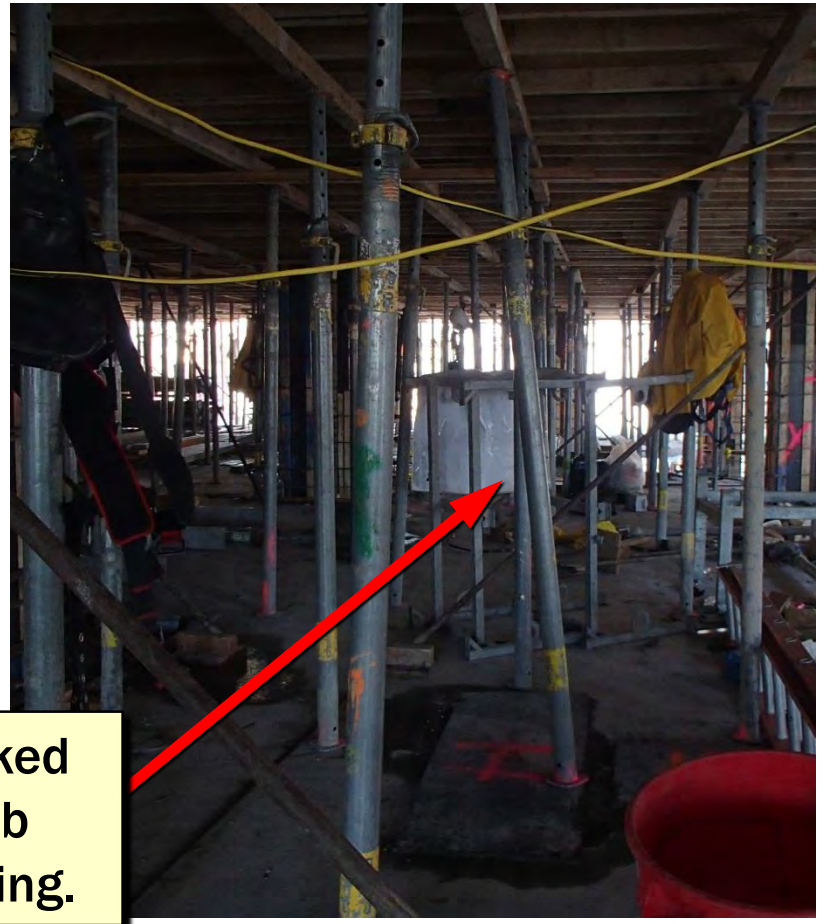
IMPROPER LATERAL BRACING



IMPROPER USAGE OF FORMS & SHORING

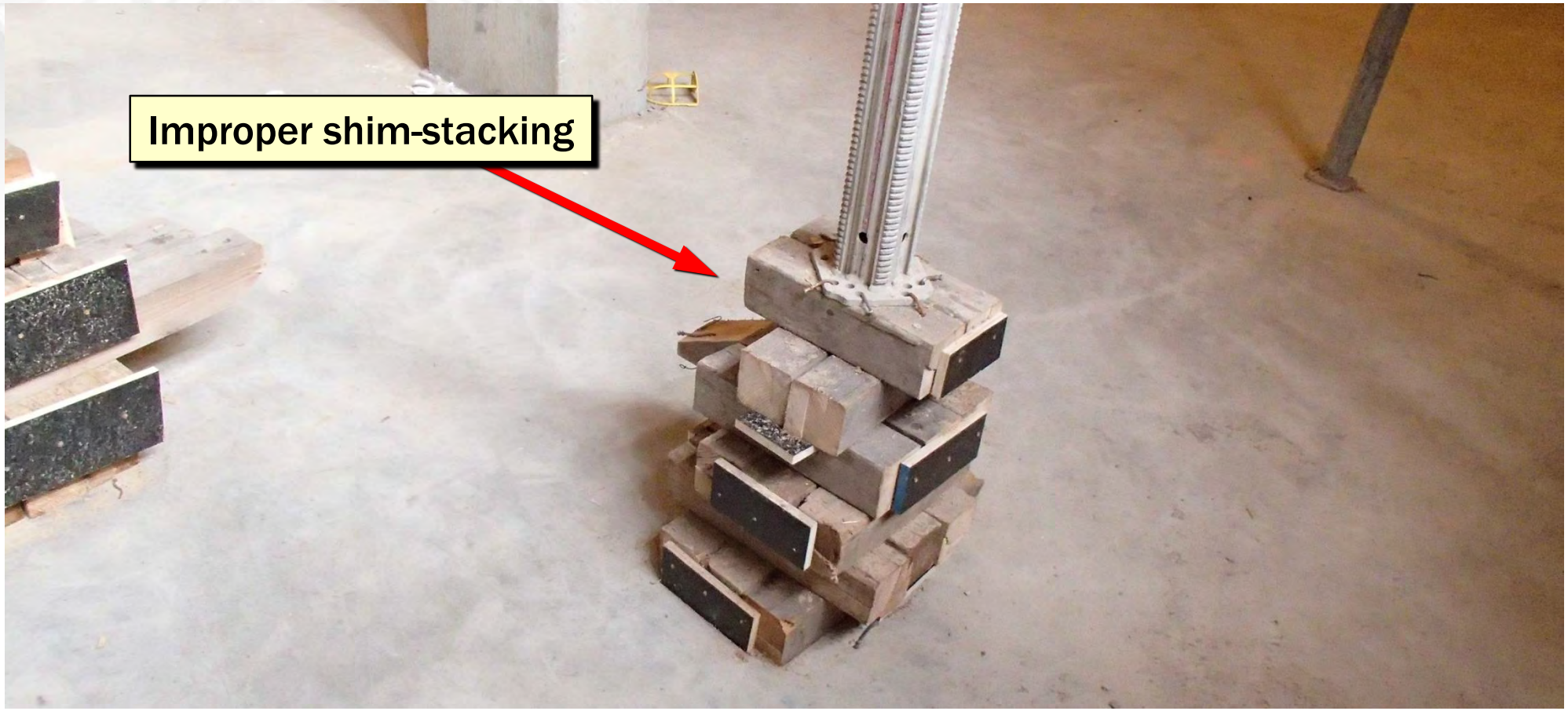


Beams not properly lapped or supported by shoring post.

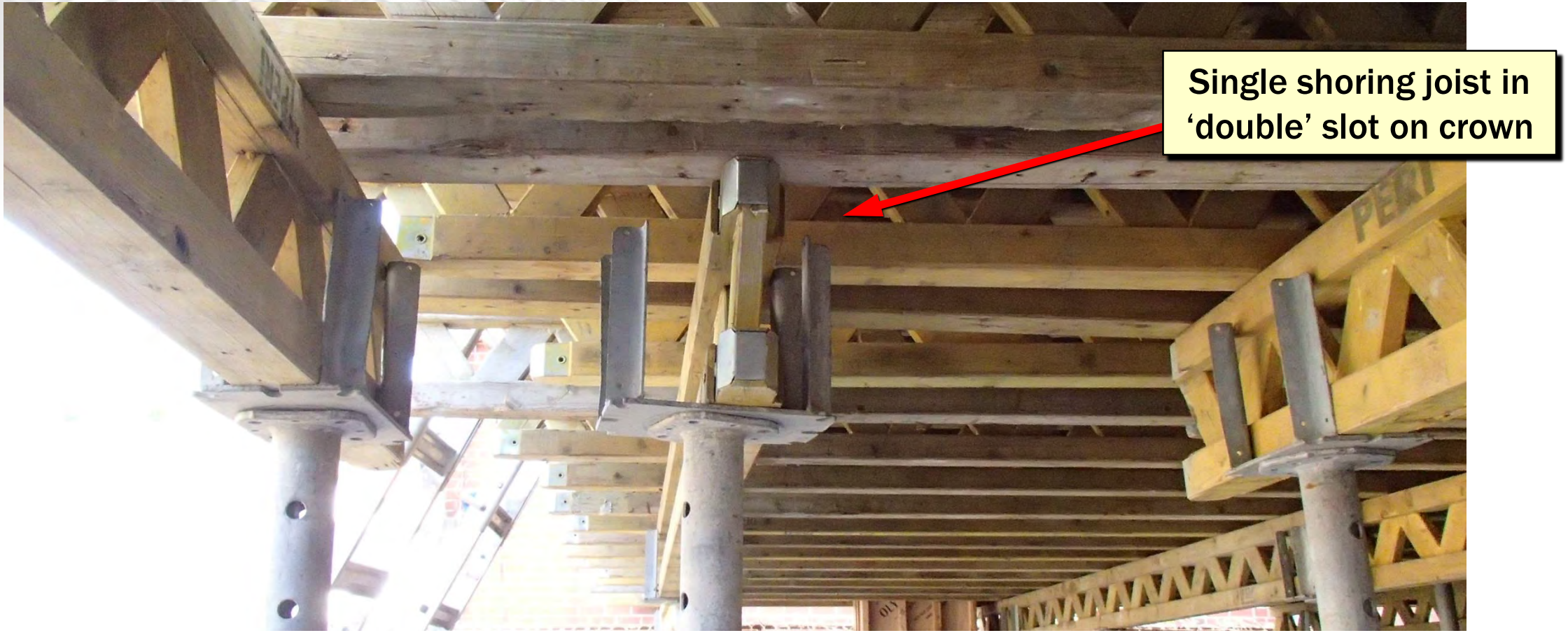


Support post kicked out to avoid slab opening. No bracing.

FORMWORK: IMPROPER USE



SHORING: IMPROPER USE OF STANDARD ITEMS



STRUCTURAL DEFICIENIES

- Non structural grout was placed within columns
- This grout is typically used to coat the inner portions of the concrete pumps and hoses
- This material is to be discarded
- Columns begin cracking
- Cracked sections show that no aggregate is visible
- Additional and unintended loads imposed

STRUCTURAL DEFICIENIES

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STRUCTURAL DEFICIENIES: ADDITIONAL SHORING & COLUMN EXPANSION REQUIRED

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EMERGENCY SHORING

Shear failure slab cracking at column shift

EMERGENCY SHORING

TEMPORARY SHORING FOR GROSS STRUCTURAL RENOVATION

THANK YOU

20 DIGITAL CONSTRUCTION
21 SAFETY CONFERENCE

NYC Buildings