State of California
Department of Industrial Relations
Division of Occupational Safety and Health

Memorandum

Date: February 19, 2021

To: Christina Shupe, Executive Officer
Occupational Safety and Health Standards Board
2520 Venture Oaks Way, Suite 350
Sacramento, CA 95833

From: Eric Berg, Deputy Chief *Eric Berg*
Division of Occupational Safety and Health

Subject: Cal/OSHA Evaluation of Petition No. 585 to amend title 8 section 1711(e)(3).

1.0 INTRODUCTION AND BACKGROUND

On June 12, 2020, the Division of Occupational Safety and Health (Cal/OSHA) received a petition to amend title 8 from Ms. Marisa "Reese" Fortin of Sundt Construction, Inc. Sundt Construction, Inc. is a construction general contractor that manages and performs construction activities including concrete, structural steel, excavation and grading, underground utilities, drainage systems, and concrete paving operations within a variety of industrial, transportation and governmental sectors. The petitioner is requesting a change to title 8 section 1711(e)(3) of the Construction Safety Orders.

Labor Code Section 142.2 permits interested persons to propose new or revised standards concerning occupational safety and health, and requires the Occupational Safety and Health Standards Board (Standards Board) to consider such proposals. California Labor Code section 147 requires the Standards Board to refer to Cal/OSHA for evaluation of any proposed occupational safety and health standard.

2.0 PETITIONER'S PROPOSED AMENDMENTS TO SUBSECTION 1711(e)(3)

Subsection 1711(e)(3) contains requirements to ensure the stability of reinforcing steel columns and other assemblies, including bracing and the design of supports. The petitioner requests an amendment to subsection 1711(e)(3) to distinguish between internal and external bracing and to allow for internal bracing to prevent collapse of reinforced steel assemblies if such bracing is designed by registered professional engineer. The additions proposed by the petitioner are shown below in underline format:

Subchapter 4. Construction Safety Orders
Article 29. Erection and Construction

§1711. Reinforcing Steel and Post-Tensioning in Concrete Construction.
* * *
(e) Stability Requirements for Vertical and Horizontal Columns, Walls, and Other Reinforcing Assemblies.

(1) Reinforcing steel for walls, piers, columns, prefabricated reinforcing steel assemblies, and similar vertical structures shall be guyed, braced, or supported to prevent collapse.
(2)(A) Systems for guying, bracing, or supports shall be designed by a qualified person.
(B) Guys, braces, and supports shall be installed and removed as directed by a competent person.
(3) Reinforcing steel shall not be used as an external guy or brace. Reinforcing steel used for internal bracing must be designed by a Registered Professional Engineer using the Load and Resistance Factor Design. Calculations must include wind and person-on-the-cage loads.

3.0 APPLICABLE FEDERAL OSHA REGULATIONS

Federal OSHA regulations address reinforcing steel in title 29 Code of Federal Regulations subpart Q (sections 1926.700 – 1926.706) Concrete and Masonry Construction. Subsection 1926.703(d)(1) addresses ensuring stability of reinforcing steel structures but does not prohibit reinforcing steel used as guys or braces.

§1926.703 - Requirements for cast-in-place Concrete.
* * *
(d) Reinforcing Steel
* * *
(1) Reinforcing steel for walls, piers, columns, and similar vertical structures shall be adequately supported to prevent overturning and to prevent collapse.
* * *

4.0 APPLICABLE CONSENSUS STANDARDS

The American National Standards Institute (ANSI) and the American Society of Safety Professionals (ASSP) address construction hazards associated with rebar assemblies in ANSI/ASSP 10.9-2013 (R2018) Safety Requirements for Concrete and Masonry Work. Section 5.4.1 of the standard prohibits the use of reinforcing steel as guying or bracing attachments to anchorage points.

ANSI/ASSP A10.9-2013 (R2018) Safety Requirements for Concrete and Masonry Work
* * *
5. REINFORCING STEEL
* * *
5.1 General. This section deals with the safe handling, installation and use of reinforcing steel on the construction site.
5.2 Guying, Support, Stability for Reinforcing Assemblies.
5.2.1 Guying. Reinforcing steel for the fabrication of walls, piers, columns and similar vertical or horizontal structures shall be guyed or supported to prevent collapse as directed by a qualified person in accordance with the site-specific safety plan.
* * *
5.4 Prohibited Uses of Reinforcing Steel.
5.4.1 Reinforcing steel shall not be used as guy/bracing attachments anchorage points.
* * *

5.0 HAZARDS TO EMPLOYEES WORKING ON AND AROUND VERTICAL AND HORIZONTAL COLUMNS, WALLS, AND OTHER REINFORCING ASSEMBLIES

The hazards relating to working upon and in proximity to rebar assemblies during construction include falls and being struck by falling objects. Lack of adequate guying, bracing, and other supports increases the likelihood of collapse or other unintended movement and could result in serious and fatal injuries including but not limited to the following:

1. Concussions
2. Fractures
3. Crushing Injuries
4. Contusions
5. Lacerations
6. Avulsions
7. Abrasions

6.0 PETITIONER'S BASIS FOR AMENDMENTS TO TITLE 8 REGULATIONS

The petitioner believes that reinforcing steel may be used effectively as internal bracing to prevent the collapse of reinforcing steel structures. It is also the petitioner's belief that the use of reinforcing steel as internal bracing can enhance employee safety.

6.1 Guying and Bracing Designed by a Competent Person Allows for Internal Reinforcing Steel Bracing

In support of the assertion that reinforcing steel may be used effectively for internal bracing, the petitioner references title 8 subsection 1711(e)(2)(A) which requires guying and bracing of reinforcing steel structures to be designed by a competent person. Based on this requirement, the petitioner argues that reinforcing steel should be permitted for bracing systems if determined adequate to prevent collapse by the competent person.

6.2 Reinforcing Steel Can Be Used Effectively as Internal Bracing

As evidence of reinforcing steel used as internal bracing, the petitioner included designs and structural analysis[1] of several reinforcing steel structures performed by Carlos A. Banchik. Mr. Banchik is the founder of Innova Technologies based in Las Vegas, Nevada and is a registered professional civil engineer in the state of Arizona. The detail design drawings included with the petition were of column and shear wall reinforcing cages for the University of Arizona Shoring Base project in Tucson, Arizona. Sizes of the columns analyzed were 16"X24", 22"X22" and 24"X24" and walls were of 10" width. Reinforcing steel brace pairs in X-configurations were incorporated in to the design at 10' maximum vertical spacing between bracing ends for columns and shear walls and 5' maximum horizontal spacing for shear walls. Each leg of the X-bracing was connected to the reinforcing steel cages by two 15-guarge double snap

[1] Banchik. *Column and Shear Wall Cages – Structural Calculations, University of Arizona Shoring Base, Tucson, Arizona*. Project No. 119-312. Innova Technologies. December, 2019.

ties[2]. Although a maximum elevation of 58 feet 6 inches was given for the structures, the maximum cage length referenced in the designs was not provided.

Analysis of the reinforcing steel cages was performed using Load Resistance Factor Design (LRFD[3]) and was based on wind forces as the maximum potential loading on the structures in addition to the weight of the cages themselves. Based on this analysis, the reinforcing steel cages could withstand, without failure, wind speeds of up to 77.25 miles per hour. The petitioner argues that the analysis performed by Mr. Banchik provides sufficient evidence that reinforcing steel bracing, when designed by a competent engineer, can be used effectively to prevent collapse of reinforcing steel structures.

As further evidence for the enhancement of structural integrity afforded to reinforcing steel structures by internal reinforcing steel braces, the petitioner also included a technical report[4] conducted by the University of Nevada's Center of Engineering Earthquake Research in November, 2010. This report details an analysis of the lateral behavior and stability of bridge column rebar cages and the potential of failure and collapse during construction.

For the analysis, two full-scale bridge column reinforcing steel cages were constructed for both internal X-bracing (Figure 1) and square bracing (Figure 2) configurations. All of the columns were 34 feet in height with a diameter of 4 feet and were constructed of #11 (1.4 in.) and #8 (1 in.) longitudinal and transverse members respectively. Two cage designs (Specimen 1 and Specimen 2) were utilized for each bracing configuration with the longitudinal and transverse members of Specimen 2 placed at half the spacing of Specimen 1 thereby incorporating twice the amount of reinforcing steel and resultant weight. Braces of both configurations were constructed of #8 (1 inch diameter) reinforcing steel and were tied with several different configurations and welded in place at 10' 6" vertical intervals. These cages were subjected to incremental loading to determine the lateral behavior, identify failure modes and determine an

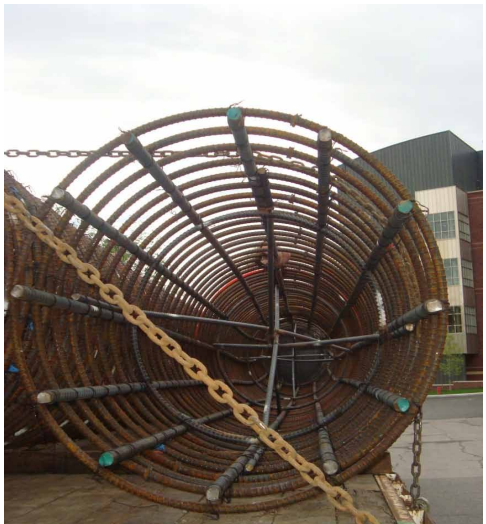

Figure 1. X-Brace Configuration

Figure 2. Square Brace Configuration

[2] A snap tie is a method of securing reinforcing steel with wire tied diagonally on two perpendicular reinforcing steel members.
[3] LRFD is an adjustment method used in structural engineering to reduce the loading capacity of a structure to ensure a conservative design.
[4] Builes-Mejia, Itani, Sedarat. *Stability of Bridge Column Rebar Cages During Construction*. Report No. CCEER 10-07. November, 2010.

appropriate analytical model. Nonlinear finite elemental analysis[5] was then developed for cages from 30 feet to 80 feet in height to determine critical parameters that affect the lateral stability and failure of bridge column reinforcing steel cages. The model utilized included two 6x19[6] Independent Wire Rope Core (IWRC) guy cables of both 3/8 inch and 5/8 inch diameters placed in horizontal and vertical directions to simulate the common practice of removing two of the four guy cables for the placement of formwork. The parameters analyzed were tie wire connections, internal braces, column diameter, longitudinal and transverse reinforcement ratios, and column height.

Based on the results of their analysis, the authors of the report concluded that internal reinforcing steel bracing significantly increased the lateral strength and stiffness for both cage designs. Table 1 below summarizes the factor of increase for lateral strength and stiffness for the cages equipped with X and square bracing configurations compared to unbraced cages.

Table 1. Factor of Increase for Strength and Stiffness of Braced Reinforcing Steel Cages

	X-Bracing Factors		**Square Bracing Factors**	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Strength	3.0	2.0	4.8	3.6
Stiffness	2.5	1.8	3.2	2.3

The petitioner asserts that results of this study provide further evidence that internal reinforcing steel bracing can be an effective method to prevent the collapse of reinforcing steel structures when designed by a competent engineer.

6.3 Internal Reinforcing Steel Bracing Can Enhance Employee Safety

The petitioner also states that using reinforcing steel as internal bracing can enhance employee safety. Since internal bracing is incorporated into the design and does not need not be adjusted or removed for the installation of formwork, the petitioner argues that the hazards associated with adjusting and removing internal bracing are eliminated. Additionally, the petitioner argues that eliminating external bracing prevents the need for coordination between the general, reinforcing steel and concrete contractors to maintain safety of reinforcing steel structures at construction sites.

7.0 ANAYLSIS

Internal braces composed of reinforcing steel are commonly used throughout industry in the construction of reinforcing steel columns, walls and other structures. Internal bracing is necessary to maintain internal support of an assembly during fabrication, when being hoisted into place, and as a component of support after the structure is in its final position prior to concrete placement. However, reinforcing steel should not be the bracing method for preventing the collapse or fall of reinforcing steel assemblies.

[5] Finite Element Analysis is an engineering analysis in which a complex system is subdivided into simpler components (elements) to determine where failure in the system could occur.
[6] A 6x19 wire rope is one constructed of 6 strands each composed of 19 individual wires.

7.1 Design and Analysis from Innova Technologies Lacks Important Information and is Overly Simplistic

Cal/OSHA disagrees that the design and analysis provided by Innova Technologies is sufficient to prove that equal safety is provided by the use of internal reinforcing steel braces to prevent collapse of reinforcing steel structures. Although the design included maximum heights of the reinforcing steel columns and walls to be 58 feet 6 inches, no maximum height was determined for which internal reinforcing steel bracing could be utilized. Wind loading was also the only force considered for the analysis. However, based on research of Cal/OSHA case history and interviews with industry professionals conducted by Research and Standards Safety Unit staff, accidental contact by machinery and equipment was one of the most common causes of reinforcing steel assembly failure. Therefore, forces other than wind should be considered when conducting such an analysis.

Additionally, the connections (boundary conditions) assumed in the analysis for the internal braces were pinned connections at both ends. This assumption allows for the braces to act as two-force members[7] and for bending moments and torsion to be ignored. Such an assumption is overly simplistic as recognized in the analysis of the University of Nevada Center of Engineering Earthquake Research report (Report No. CCEER 10-07) for which the brace boundary conditions were assumed to be semi-rigid and were analyzed not only for tension and compression but also bending and torsion.

7.2 The University of Nevada Center of Engineering Earthquake Research Report Does Not Indicate Internal Braces are Sufficient to Prevent Collapse

Although the report from the University of Nevada Center of Engineering Earthquake Research included a very comprehensive analysis of the effects of internal reinforcing bracing on the stability of reinforcing steel structures, there is no indication that this type of bracing could be used exclusively for support. Cal/OSHA agrees that internal reinforcing steel bracing is not only beneficial but necessary to maintain stability and structural integrity of reinforcing steel structures. The report clearly indicates a significant increase in the strength and stiffness of braced reinforcing steel structures; however, the analysis was based on bridge columns supported not only by internal bracing but also by two guy wires. One of the central purposes of the study was to increase the stability of bridge columns when guy or braces supports are removed to allow for the installation of concrete formwork. Cal/OSHA believes that the authors of the study did not intend reinforcing steel braces to serve as the only means of support for reinforcing steel structures.

7.3 The Petitioner's Claim that Removal of External Bracing Poses a Serious Hazard is Not Substantiated

The petitioners claims that the removal of external bracing of reinforcing steel structures poses a serious hazard to employees. However, no information was provided by the petitioner on the specific hazard(s) of this claim. If the hazard to which the petitioner refers is the collapse of reinforcing steel structures, then the root cause of the hazard is insufficient bracing and/or guying of the structure rather than removal of the support.

[7] Two-force members are components of a structural system in which only tension and compression forces are assumed to be present.

A search of Cal/OSHA's investigative history conducted by Research and Standards Safety Unit staff did reveal that one of the most common causes of reinforcing steel structure failure was removal of bracing or insufficient support. However, if a brace or other support must be removed for the installation of formwork or other activities, the structure must be adequately supported to prevent collapse thereby eliminating the hazard of collapse for employees removing the supports.

7.4 The Petitioner's Argument that Internal Bracing Eliminates the Need for Coordination at Worksites is Contrary to Employee Safety

The petitioner argues that utilizing internal reinforcing steel bracing for reinforcing steel structures eliminates the need to remove external bracing thereby eliminating the need for coordination between the general, concrete, reinforcing steel, formwork and other contractors to maintain safety.

Such an argument is contrary to employee safety and title 8 subsection 1711(d). Effective communication and coordination between contractors at a worksite must always be maintained to ensure safety for employees.

8.0 CONCLUSION - DENY

Cal/OSHA agrees that reinforcing steel bracing, when properly designed and installed, enhances the strength, stiffness and resulting stability of reinforcing steel structures and can be a necessary element for their construction. Such bracing could be used in addition to other supports but should not be allowed as the sole means of bracing for reinforcing steel structures. Therefore, Cal/OSHA recommends that the petition be DENIED.