DSA IR 16-10

CARGO CONTAINER CONVERSION TO MODULAR SCHOOL BUILDINGS: 2019 CBC

Disciplines: All

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Division of the State Architect (DSA) documents referenced within this publication are available on the DSA Publications webpages.

PURPOSE

This Interpretation of Regulations (IR) clarifies the requirements for the conversion of cargo containers to modular school buildings, as accepted by DSA.

SCOPE

This IR is applicable to the conversion of cargo containers to modular school buildings. Selection, structural integrity verification, and other basic requirements of the cargo containers are covered. For cargo container use for storage as non-school buildings refer to *IR A-27, Cargo Containers Used as Storage*.

BACKGROUND

For reasons of both sustainability and economy, the use of cargo containers (also known as cargo boxes, sea vans, shipping containers, or conexs) in building construction is growing.

Cargo container is defined in the Code of Federal Regulations (CFR), Title 49, Section 450.3. It is an article of transport equipment that is:

- Of a permanent character and suitable for repeated use.
- Specially designed to facilitate the transport of goods, by one or more modes of transport (rail, truck or ship), without intermediate reloading.
- Designed to be secured and readily handled, having corner fittings for these purposes.
- Of a size that the area enclosed by the four outer bottom corners is either:
  - At least 150 square feet (sq.ft.).
  - At least 75 sq. ft. if it has top corner fittings.

See CFR, Title 49, Section 450.3 for additional requirements.

Cargo containers are manufactured worldwide to meet the standards set by the International Convention of Safe Containers (CSC). The CSC is an international agreement ratified by various countries including the United States. Inspection and testing services at the point of manufacture of the cargo containers are provided by a Certified Inspection and Testing Agency (CITA) specifically authorized to certify containers by an administration signatory to the CSC. The selected CITA inspects the cargo containers at the point of manufacture, and if they pass the inspection, places a CSC safety approval placard (CSC plate) on each container and assigns a unique CSC tracking number to each container. The inspected containers will also have the selected CITA organization logo affixed to them.

In this IR, a cargo container is also referred to as a module. Two or more modules joined together form a unit, such as a classroom unit.

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1. SELECTION OF CONTAINERS FOR CONVERSION ←

1.1 The container shall be general purpose container conforming to ISO 1496-1 issued by the International Organization for Standardization.

1.2 The container shall have an affixed CSC approval placard (see Appendix A for sample placard). It shall have been surveyed and verified by a Licensed Marine Surveyor as undamaged, and must not have been used after the survey. A copy of the survey and verification forms completed and signed by the Licensed Marine Surveyor shall be placed in the container and shall be made available to the in-plant and project inspectors.

1.3 Container shall have one of the following CITA logos affixed to it:

- American Bureau of Shipping (ABS)
- Bureau Veritas (BV)
- Det Norske Veritas AS (DNV)
- Det Norske Veritas Germanischer Lloyd (DNV GL)
- Germanischer Lloyd (GL)
- Lloyd's Register (LR)

Containers bearing other CITA logos can be used, subject to DSA approval. The modular building manufacturer shall submit for DSA review, the CITA rules and guidelines for container certification.

1.4 Container shall not have been manufactured earlier than 24 months from the date of DSA approval of the site-specific or stockpile modular school building design drawings.

1.5 Container shall be undamaged and have no previous repairs.

1.6 Container type shall be standard dry cargo container, used for the transportation of dry goods only. Container shall not have been used for transporting hazardous materials. Container shall not have been painted with paint containing lead.

1.7 Manufacturer's original design/fabrication drawings for the container, with english translation when necessary, shall be provided to the in-plant and project inspectors for the verification and evaluation of the as-built container material and member properties, and connection details. For the existing floor plywood sheathing, specifications for the plywood, exposure category, and expected identification/certification marks on the panel should be noted on drawings. Existing plywood shall meet or exceed performance requirements specified in the Institute of International Container Lessors, *Performance Standard for New and Unused Structural Container Floor Panels To Be Installed in International Freight Containers* (IICL TB 001).

1.8 Copies of selected original design/fabrication drawings of the cargo container shall be included as a part of the modular school building plan review submittal as a "Reference Only" supporting document in accordance with *PR 18-04 Electronic Plan Review for Design Professional of Record*, Section 1.2.5. The structural engineer in responsible charge shall develop as-built drawings for the cargo container showing the complete as-built information required for verification and evaluation of the unmodified cargo container and include them as a part of the modular school building construction documents. The structural engineer in responsible charge shall compute the geometric section properties of all the existing structural elements of the cargo container and include this information in the as-built drawings. The structural engineer in responsible charge shall stamp and sign the as-built drawings.

2. STRUCTURAL INTEGRITY VERIFICATION OF EACH UNMODIFIED CONTAINER

2.1 Comprehensive condition assessment per the American Society of Civil Engineers (ASCE) 41 Sections 9.2.3 (and 12.2.3 if applicable) and non-destructive weld testing (NDT) shall be performed in the US by a laboratory accepted by the DSA Laboratory Evaluation and Acceptance (LEA) program after the container is purchased by the company performing the conversion to a modular school building and prior to the start of construction or rehabilitation on the container. The school district shall pay for the structural integrity verification of each unmodified container except when it is for a modular building manufacturer's stockpile. If it is for a modular building manufacturer's stockpile, the modular building manufacturer shall pay for the structural integrity verification of each unmodified container in accordance with *IR A-31: Project Inspection of School Buildings Owned by a Non-School Entity*. The in-plant verification for the modular building manufacturer's stockpile shall be per IR A-31.

2.2 If the design of the converted building requires the structural steel and/or cold-formed steel material(s) used in the orginal cargo container construction to exceed a yield strength of 50 kips per square inch (ksi), the material shall be validated by comprehensive material testing in accordance with ASCE 41 Section 9.2.2.4.2.

2.3 Perform the following inspection tasks:

2.3.1 Verify the selected container complies with all the requirements specified in Section 1 above.

2.3.2 Visually inspect each container to verify that the container is consistent with the container manufacturer's design drawings, is not damaged, and is structurally sound. The acceptable tolerances shall not exceed those given in the American Institute of Steel Construction (AISC) Code of Standard Practice for Steel Buildings and Bridges (AISC 303).

2.4 The general condition assessment of the container and the visual inspection of welds shall be performed by an American Welding Society – Certified Welding Inspector (AWS-CWI), employed by a laboratory certified by the LEA program. NDT of existing container fillet welds shall be performed by a qualified Level II NDT technician employed by the laboratory. This examination shall be made using the magnetic particle method unless approved otherwise by DSA. If sub-surface discontinuities are suspected, alternate methods of NDT may be utilized as approved by DSA. For container with failed welds, prepare written repair procedures for DSA review and approval prior to start of repair work (refer to Section 2.7 below). Alternatively, a different container could be used for conversion into a school building.

2.4.1 Corner Casts - visually inspect all welds connecting the corner casts to the beams and columns. Perform NDT of at least one weld connecting the corner cast to the beam or column. If the weld fails, NDT all similar welds to beams and columns.

2.4.2 Floor Joists - visually inspect all welds connecting the floor joists to the side rails (beams). Perform NDT of at least one weld connecting the floor joists to side rail. If the weld fails, NDT all similar welds.

2.4.3 Metal Siding - visually inspect all welds connecting the metal siding to posts and beams. Perform NDT of at least one weld connecting the metal siding to post or beam. If the weld fails, NDT all similar welds.

2.4.4 Metal Roof Deck - visually inspect all welds connecting the metal roof deck to the header and rails (beams). Perform NDT of at least one weld connecting the metal roof deck to the beam. If the weld fails, NDT all similar welds.

2.5 If existing plywood floor sheathing is going to be retained, confirm that it is not damaged and confirm that the plywood sheets have the identification/certification marks consistent with

the original container design drawings and IICL TB 001. Inspect the plywood using procedures similar those described by IICL.

2.5.1 Tap the plywood floor with a hammer searching for hollow sounds, which will indicate delamination.

2.5.2 Look for obvious signs of failure in the plywood panels such as waviness and/or bulges on the outer plies, and cracks in the outer (usually lower) plies.

2.5.3 Look for visible permanent downward deflection in the plywood floor panels.

2.5.4 Plywood floor panels indicating hollow sounds, waviness, bulges, cracks, permanent deflection and gouges, etc. are unsuitable for school construction and shall not be retained. Only plywood floor panels without any noticeable damage may be retained.

2.5.5 Verify if the existing plywood was treated with chemicals. Determine if the chemicals used are harmful to humans, such as ammonia or arsenate based preservatives.

2.6 A detailed written report verifying the condition, sealed by a California licensed professional engineer shall be prepared by the laboratory documenting the visual inspections, test results, and general condition assessment for each container. Copies shall be distributed to DSA, the owner, and the project inspector. A copy of the report shall be placed in the module and shall be made available for inspections both in the plant and at the site.

2.7 Should any finding in the report constitute a deviation from the approved construction documents or the original design/fabrication drawings (see Section 1.8 above) the design team shall prepare and submit to DSA for review and approval, a Construction Change Document (CCD) defining the required corrective work. Refer to *IR A-6: Construction Change Document Submittal and Approval Process*.

3. BASIC REQUIREMENTS

All portions of modular school buildings shall conform to all requirements of the building standards adopted for public schools in California Code of Regulations (CCR) Title 24 and as interpreted in this IR. The State Fire Marshal and accessibility regulations shall be complied with. Each time a modular building is relocated, plans shall be submitted to DSA for approval.

3.1 Lateral Force Resisting System

3.1.1 The seismic force resisting system shall be one defined in ASCE 7 Table 12.2-1 as permitted by DSA in accordance with the California Building Code (CBC).

3.1.2 The contribution of the corrugated steel container sides, if left in place, to the lateral force resistance is to be neglected, unless testing and analysis is provided to justify an alternate system in accordance with California Administrative Code (CAC) Section 4-304 in accordance with one of the following:

3.1.2.1 Equivalency to a system in ASCE 7 Table 12.2-1 in accordance with Federal Emergency Management Agency (FEMA) P-795.

3.1.2.2 New seismic design parameters (response modification factor, overstrength factor, deflection amplification factor, etc.) specific to this system are developed in accordance with FEMA P695.

3.1.3 The container steel frame contribution to the lateral force resistance, if any, is to be neglected even in cases where the container siding is removed. The seismic performance of the container steel frames cannot be estimated reliably at this time due to the presence of the corner cast at the beam-column joint, and due to the splicing of the steel columns at the beam-column joint in the stacked frame arrangement. The section shapes and sizes of some of the

existing container beams and columns also indicate that the contribution of the existing steel framing to the lateral force resistance will not be significant. Due to the above reasons, the contribution of the existing steel frames to lateral force resistance shall be ignored.

3.1.4 Deformation compatibility of structural elements that are not included in the seismic force resisting system shall be considered in the analysis. Considering that, the stiff corrugated steel siding at the modular building perimeter will usually be retained and will not be seismically separated, the relatively flexible lateral force resisting systems such as steel moment frames are not considered suitable for container conversion. For the conversion of cargo containers to modular school buildings, shear walls and braced frames designed with adequate stiffness are considered suitable as vertical elements of the lateral force resisting system. Although because of the lack of substantial testing and analysis, the contribution of the container corrugated steel siding to the lateral force resistance is to be neglected, the in-plane stiffness of the corrugated steel siding shall not be ignored and shall be considered when verifying stiffness irregularities. The total length of siding (less openings) along a line in a lower story shall not be less than 80% of the total length of siding (less openings) along the same line in the story immediately above.

3.1.5 For the corrugated roof metal deck, the roof diaphragm capacity may be determined per the Steel Deck Institute Diaphragm Design Manual (SDI DDM). For the floor with plywood sheathing over cold formed steel joists, the floor diaphragm capacity shall be determined per American Iron and Steel Institute (AISI) S400. Adjacent modules within the unit shall be positively connected to each other such that the unit will perform as one structure. Adjacent units shall be either positively connected to each other such that the units together will perform as one structure or structurally separated with adequate gap between them such that each unit will perform as a separate structure. Diaphragms, chords, and collectors shall be designed and detailed to satisfy ASCE 7 Section 12.10. The required structural separation between the modular building and any adjacent structure (elevators, stairs, etc.) shall be shown on the modular building design drawings.

3.1.6 All structural elements and details shall be justified through engineering calculations, in accordance with the current CBC.

3.2 Site Plan Requirements: See *IR 16-1: Design and Construction Requirements for Relocatable Buildings and Modular Elevator Towers*, Section 1.

3.3 Protection Against Deterioration: See IR 16-1 Section 2.1.

3.4 Grade Clearance

The distance below the underside of the plywood floor sheathing to the exposed soil shall not be less than 18 inches unless the plywood is pressure treated. In cases where the existing marine grade plywood floor sheathing is to be replaced by new plywood sheathing and the distance to the exposed soil is less than 18 inches, the new plywood shall be pressure treated and have the exposure durability classification - Exterior. All pressure treated plywood shall be verified to be harmless to humans or shall be encapsulated. Submit encapsulating details for DSA review. See also IR 16-1 Section 2.2.

3.5 Electrical, Mechanical and Plumbing: See IR 16-1, Section 2.5.

3.6 Permanent Foundations: See IR 16-1, Section 3.1.

3.7 Non-Permanent Foundations: See IR 16-1, Section 3.2. Where net uplift forces occur, design the foundations to resist the calculated uplift forces. ←

4. SPECIAL REQUIREMENTS

4.1 Container Identification

The modular building manufacturer that is converting and assembling the container modules into modular school building shall assign its own unique serial number for each container module. Corresponding to each unique serial number assigned, the modular building manufacturer shall indicate the corresponding CSC number of the container module used in assembling the modular building. The modular building manufacturer shall make the above information available to the owner, project inspector, and DSA along with copies of relevant CSC placards. A copy of the above information shall be placed in the container module and shall be made available for inspections both in the plant and at the site. All the above information shall be included in the final verified reports prepared by the contractor and the project inspector.

See IR 16-1 Section 4.1 for further requirements.

4.2 Floor Live Load and Roof Snow Load Posting: See IR 16-1 Section 4.2.

5. RELOCATION OF EXISTING RELOCATABLE SCHOOL BUILDING

See IR 16-1 Section 5.

6. COMPLIANCE WITH CALGREEN CODE (CCR,TITLE 24, PART 11)

See IR 16-1 Section 6.

7. COMPLIANCE WITH THE ENERGY CODE (CCR, TITLE 24, PART 6)

See IR 16-1 Section 7.

REFERENCES:

2019 California Code of Regulations (CCR), Title 24
- Part 1: California Administrative Code (CAC), Section 4-304
- Part 2: California Building Code (CBC)
- Part 6: California Energy Code
- Part 11: California Green Building Standards Code (CALGreen)

Code of Federal Regulations (CFR), Title 49, Section 450.3

Federal Emergency Management Agency (FEMA) P695: Quantification of Building Seismic Performance Factors

Federal Emergency Management Agency (FEMA) P-795: Quantification of Building Seismic Performance Factors: Component Equivalency Methodology

International Organization for Standardization
- ISO 1496-1, Series 1 Freight Containers – Part 1: General cargo containers for general purposes

Steel Deck Institute Diaphragm Design Manual (SDI DDM), Fourth Edition

This IR is intended for use by DSA staff and by design professionals to promote statewide consistency for review and approval of plans and specifications as well as construction oversight of projects within the jurisdiction of DSA, which includes State of California public schools (K–12), community colleges and state-owned or state-leased essential services buildings. This IR indicates an acceptable method for achieving compliance with applicable codes and regulations, although other methods proposed by design professionals may be considered by DSA.

This IR is subject to revision at any time. Please check DSA's website for currently effective IRs. Only IRs listed on the webpage at www.dgs.ca.gov/dsa/publications at the time of project application submittal to DSA are considered applicable.

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Appendix A - Sample Placard