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Fire Safety Evaluation of Existing Manufactured Educational Building Covered by Section 423 of the *Florida Building Code*

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Disclaimer: This report covers a specific single modular classroom and a specific cluster building and may not address all of the concerns of the Authority having Jurisdiction.

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Scope:

- Task 1: Perform a fire safety evaluation of the existing manufactured modular classroom and educational building composed of 12 modular classrooms. The fire safety evaluation was done based on the criteria in Chapter **12 COMPLIANCE ALTERNATIVES** of the *Florida Building Code* for *Existing Buildings*, Section **1201.6 Evaluation process**.
- Task 2: Investigate using Section **104.11 Alternative materials, design and methods of construction and equipment** of the *Florida Building Code, Buildings* using the *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings* as another evaluation method to determine the fire safety of these buildings.

The fire safety of the manufactured modular classroom and educational building is to be based on the minimal type of construction allowed under Section **423.8.3 Construction type**. The evaluation was based on a Type IIB construction with cement bonded particle board (CBPB) floor system. This evaluation was limited to the designs as described on the drawings (See references).

References:

1. *Florida Building Code, Building* 2004 edition with 2006 Supplement
2. *Florida Building Code, Existing Building* 2004 edition with 2006 Supplement
3. Classroom drawing file – CRA0549.14 drawings
4. Building drawing file – CRA06045-01

Task 1:

Singular Modular Classroom: The classroom is a single story building of 840 ft² (23' 4" by 36' 0"). The classroom has a single exit and three windows and a restroom facility for one occupant.

Classroom Evaluation under Section 1201.6:

1201.6.1.1 Height formula

AH = Allowable height in feet from FBCB – Table 503
AH = 55 feet (Type IIB construction)

EBH = Existing building height in feet
EBH = ½" + 1-½" + 6" + 10' 6" + ¾" + 10" + 24" = 14' ¾"

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$$AH - EBH = 55' - 14' - 3/4'' = 40' 11 - 1/4''$$

CF = 1 if AH – EBH is positive

$$\text{Height Value, feet} = \frac{AH - EBH}{12.5} \times CF$$

$$\text{Height Value, feet} = \frac{(55 - 14' 3/4'')1}{12.5} = \frac{(40' 11 - 1/4'')1}{12.5} = 3.275$$

AS = Allowable height in stories from FBCB – Table 503

AS = 2 stories

EBS = Existing building height in stories

EBS = 1 story

Height Value, stories = AS – EBS x CF

$$\text{Height Value, stories} = (2 - 1)1 = 1$$

Use Height Value, stories = (2 – 1)1 = 1

1201.6.2.1 Allowable area formula

I_s = Percent area increase due to sprinkler protection

$$I_s = 0\%$$

I_f = Percent area increase due to frontage

$$I_f = 0\%$$

A_t = Allowable area per floor from FBCB – Table 503

$$A_t = 14,500 \text{ sq ft (Type IIB construction)}$$

A_a = Allowable area per floor

$$A_a = \frac{(100 + I_s + I_f)}{100} \times A_t = \text{Allowable area per floor from FBCB – Table 503}$$

$$A_a = \frac{(100 + 0 + 0)14,500 \text{ ft}^2}{100} = 14,500 \text{ ft}^2$$

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1201.6.2.2 Area formula

$$\text{Actual area} = (23' 4'')(36' 0'') = 840 \text{ ft}^2$$

$$\text{Area Value} = \frac{\text{Allowable area}}{1,200 \text{ ft}^2} \left(1 - \frac{\text{Actual area}}{\text{Allowable area}}\right)$$

$$\text{Area Value} = \frac{14,500 \text{ ft}^2}{1,200 \text{ ft}^2} \left(1 - \frac{840 \text{ ft}^2}{14,500 \text{ ft}^2}\right) = \frac{14,500 \text{ ft}^2}{1,200 \text{ ft}^2} (1 - 0.058) = 11.38$$

1201.6.3 Compartmentation

$$\text{Compartment size} = \text{Actual area} = (23' 4'')(36' 0'') = 840 \text{ ft}^2$$

$$\text{Compartment category} = \text{Category e}$$

$$\text{Compartment value, CV} = 20$$

FBCB – Table 1201.6.3

1201.6.4 Tenant and Dwelling Unit Separation

Not applicable

1201.6.5 Corridors Walls

Not applicable

1201.6.6 Vertical Opening

Not applicable

1201.6.7 HVAC Systems

HVAC system category = Category d

HVAC value = 0

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1201.6.8 Automatic Fire Detection

Automatic fire detection category = Category a
(Worse case scenario based on classroom not having a closet.)

Automatic fire detection value = -4

1201.6.9 Fire Alarm System

Fire alarm system category = Category c
(Worse case scenario based on plans requiring fire alarm installed by others.)

Fire alarm system value = 0

1201.6.10 Smoke Control

Smoke control system category = Category a

Smoke control system value = 0

1201.6.11 Means of Egress Capacity

Means of egress capacity category = Category c
(Worse case scenario based on no secondary door being provided.)

Means of egress capacity value = 2

1201.6.12 Dead Ends

Not applicable
(Classroom is not required to have more than one means of egress.)

1201.6.13 Maximum Exit Access Travel Distance

Maximum allowable travel distance = 75 feet

Actual allowable travel distance = 45 feet

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Maximum exit access travel distance value =

$$\frac{20(\text{Maximum Allowable Travel Distance} - \text{Maximum Actual Travel Distance})}{\text{Maximum Allowable Travel Distance}}$$

$$\text{Maximum exit access travel distance value} = \frac{20(75' - 45')}{75'} = 8$$

1201.6.14 Elevator Control

Elevator control value = 0

1201.6.15 Means of Egress Emergency Lighting

Means of egress emergency lighting category = Category c

Means of egress emergency lighting value = 1

1201.6.16 Mixed Occupancies

Mixed occupancies value = 0

1201.6.17 Automatic Sprinklers

Automatic sprinklers category = Category c

Automatic sprinklers category value = 0

1201.6.18 Standpipes

Standpipes category = Category b

Standpipes category value = 0

1201.6.19 Incidental Use Area Protection

Incidental use area protection required = none

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Incidental use area protection provided = none

Incidental use area protection value = 0

Single Modular Classroom

Summary Evaluation Process			
SAFETY PARAMETERS	FIRE SAFETY (FS)	MEANS OF EGRESS (ME)	GENERAL SAFETY (GS)
1201.6.1 Building Height	1	1	1
1201.6.2 Building Area	11	11	11
1201.6.3 Compartmentation	20	20	20
1201.6.4 Tenant and Dwelling Unit Separation	0	0	0
1201.6.5 Corridors Walls	0	0	0
1201.6.6 Vertical Opening	0	0	0
1201.6.7 HVAC Systems	0	0	0
1201.6.8 Automatic Fire Detection	-4	-4	-4
1201.6.9 Fire Alarm System	0	0	0
1201.6.10 Smoke Control	.....	0	0
1201.6.11 Means of Egress Capacity	.....	2	2
1201.6.12 Dead Ends	.....	0	0
1201.6.13 Maximum Exit Access Travel Distance	.....	8	8
1201.6.14 Elevator Control	0	0	0
1201.6.15 Means of Egress Emergency Lighting	.....	1	1
1201.6.16 Mixed Occupancies	0	.....	0
1201.6.17 Automatic Sprinklers	0	0	0
1201.6.18 Standpipes	0	.....	0
1201.6.19 Incidental Use Area Protection	0	0	0
Building Score – Total Value	28	39	39

Mandatory Safety Scores			
Occupancy	FIRE SAFETY (FS)	MEANS OF EGRESS (ME)	GENERAL SAFETY (GS)
Education	29	40	40

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Evaluation Formulas		
Formula	Calculations	Pass/Fail
FS – MFS > 0	28 – 29 = -1	Fail
ME – MME ≥ 0	39 – 40 = -1	Fail
GS – MGS ≥ 0	39 – 40 = -1	Fail

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Conclusion for Classroom: The fire safety evaluation of the classroom indicates that the classroom is below the mandatory fire safety criteria of Section 1201.6. The evaluation scores can be improved to meet or exceed the mandatory fire safety criteria by one or more of the following actions. Several of these features may already have been completed during the installation of the classroom since the drawings. The drawings indicate that several of these fire safety features were to be done by others during the installation of the classroom. If any of these fire safety features were installed by others, the evaluation scores will increase sufficiently to meet or exceed the mandatory fire safety criteria.

Automatic Fire Detection: If smoke detectors indicated on the drawings have been installed, the Automatic Fire Detection Category can be changed from a “Category a” with a value of -4 to a “Category c” or “Category d” or “Category e”. A change to a “Category c” or “Category d” or “Category e” will increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy.

A “Category c” will require the installation of smoke detectors in the HVAC system to prevent the distribution of smoke within the classroom by the HVAC system. The activation of the smoke detector will shut down the HVAC system and sound an alarm in the classroom. The activation of the smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category c” is zero.

A “Category d” will require the installation of smoke detectors in the ceilings of the restroom and closet. The activation of any smoke detectors will sound an alarm in the classroom. The activation of any smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category d” is 4.

A “Category e” will require the installation of smoke detectors in the ceilings of the classroom, restroom, and closet. The activation of any smoke detector will sound an alarm in the classroom. The activation of any smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category e” is 8.

Fire Alarm: If the manual fire alarm system indicated on the drawings has been installed, the Fire Alarm Category can be changed from a “Category c” with a value of zero to “Category d” or “Category e”. The change to a “Category e” will increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy.

A “Category d” will require the installation of a fire alarm in accordance with NFPA 72. Since the classroom is not required by the Florida Building Code to have a manual fire alarm, the installation of the fire alarm will exceed the minimum code requirement. The evaluation value of a “Category d” is 3.

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A “Category e” will require the installation of a fire alarm in accordance with NFPA 72 with an emergency voice/alarm communication system and a fire command station to comply with Section 403.8. The evaluation value of a “Category e” is 5.

Automatic Sprinklers: Automatic sprinklers are not required and were not provided so the evaluation category is “Category c”. Changing the “Category c” with a value of zero to “Category f” will increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy.

A “Category f” will require the installation of a sprinkler system complying with Section 903.3.1.1. The evaluation value of a “Category f” is 18.

Summary: To develop evaluation scores that are equal to or exceed the required mandatory safety scores, it will be necessary to install at least one of the following six modifications:

Automatic Fire Detection (smoke detectors)

“Category c”

“Category d”

“Category e”

Fire Alarm (manual fire alarm)

“Category d”

“Category e”

Automatic Sprinklers (sprinklers)

“Category f”

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Task 1:

Educational Building: The educational building consists of 12 modular classrooms with an 8' wide exit access corridor along the centerline of the building. The educational building is a single story building with an area of 11,152 ft² (68' 0" by 164' 0"). There are six classrooms side by side along each side of the exit access corridor. The exit access is designed as a 1-hour fire rated corridor with a pair of double egress doors at each end.

The individual classrooms are composed of two modules with a total length and width of 27' 4" by 29' 5". The classroom has a single egress door and four egress windows, a restroom facility for one occupant with an adjoining closet. Access to the restroom is through the closet.

Building Evaluation under Section 1201.6:

1201.6.1.1 Height formula

AH = Allowable height in feet from FBCB – Table 503

AH = 55 feet (Type IIB construction)

EBH = Existing building height in feet

EBH = 12' 10-1/2" + 24" = 14' 10-1/2"

AH – EBH = 55' – 14' 10-1/2" = 40' 1-1/2"

CF = 1 if AH – EBH is positive

Height Value, feet = $\frac{AH - EBH}{12.5} \times CF$

Height Value, feet = $\frac{(55 - 14' 10-1/2'')1}{12.5} = \frac{(40' 1-1/2'')1}{12.5} = 3.21$

AS = Allowable height in stories from FBCB – Table 503

AS = 2 stories

EBS = Existing building height in stories

EBS = 1 story

Height Value, stories = AS – EBS x CF

Height Value, stories = (2 – 1)1 = 1

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Use Height Value, stories = (2 – 1)1 = 1

1201.6.2.1 Allowable area formula

I_s = Percent area increase due to sprinkler protection

$$I_s = 0\%$$

I_f = Percent area increase due to frontage

$$I_f = 0\% \quad (\text{Worse case scenario.})$$

A_t = Allowable area per floor from FBCB – Table 503

$$A_t = 14,500 \text{ sq ft (Type IIB construction)}$$

A_a = Allowable area per floor

$$A_a = \frac{(100 + I_s + I_f)}{100} \times A_t = \text{Allowable area per floor from FBCB – Table 503}$$

$$A_a = \frac{(100 + 0 + 0)14,500 \text{ ft}^2}{100} = 14,500 \text{ ft}^2$$

1201.6.2.2 Area formula

$$\text{Actual area} = (68' 0'')(164' 0'') = 11,152 \text{ ft}^2$$

$$\text{Area Value} = \frac{\text{Allowable area}}{1,200 \text{ ft}^2} \left(1 - \frac{\text{Actual area}}{\text{Allowable area}}\right)$$

$$\text{Area Value} = \frac{14,500 \text{ ft}^2}{1,200 \text{ ft}^2} \left(1 - \frac{11,152 \text{ ft}^2}{14,500 \text{ ft}^2}\right) = \frac{14,500 \text{ ft}^2}{1,200 \text{ ft}^2} (1 - 0.769) = 2.79$$

1201.6.3 Compartmentation

$$\text{Compartment size} = \text{Actual area} = (68' 0'')(164' 0'') = 11,152 \text{ ft}^2$$

Compartment category = Category a

$$\text{Compartment value, CV} = 4$$

FBCB – Table 1201.6.3

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1201.6.4 Tenant and Dwelling Unit Separation

Not applicable

1201.6.5 Corridors Walls

Corridor wall – 1-hour wood stud corridor walls conforming to UL Design U305

Corridor wall category = Category c

Corridor wall value = 0

1201.6.6 Vertical Opening

Not applicable

1201.6.7 HVAC Systems

HVAC system category = Category e

HVAC value = 5

1201.6.8 Automatic Fire Detection

Automatic fire detection category = Category a

Automatic fire detection value = -4

1201.6.9 Fire Alarm System

Fire alarm system category = Category c

(Worse case scenario based on plans requiring fire alarm installed by others.)

Fire alarm system value = 0

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1201.6.10 Smoke Control

Smoke control system category = Category a

Smoke control system value = 0

1201.6.11 Means of Egress Capacity

$$\text{Occupant Load} = \frac{(29' 5'')(27' 4'') - (15' 9'')(6' 1'')}{20 \text{ ft}^2/\text{occupant}} = \frac{708 \text{ ft}^2}{20} = 35.4 \quad \text{use 36 occupants}$$

Occupant Load = 36 occupants (12 classrooms) = 432 occupants

Egress width = 432 occupants (0.2"/occupant) = 86.4"

Egress width provided = 2(72") = 144"

Egress over capacity = $\frac{144''}{86.4''} = 166\%$

Means of egress capacity category = Category c
(No credit given for egress windows since egress windows are not exits.)

Means of egress capacity value = 2

1201.6.12 Dead Ends

Dead end category = Category c

Dead end value = 2

1201.6.13 Maximum Exit Access Travel Distance

Maximum allowable travel distance = 150 feet

Actual allowable travel distance = 123' 7"

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Maximum exit access travel distance value =

$$\frac{20(\text{Maximum Allowable Travel Distance} - \text{Maximum Actual Travel Distance})}{\text{Maximum Allowable Travel Distance}}$$

$$\text{Maximum exit access travel distance value} = \frac{20(150' - 123' 7'')}{150'} = 3.52$$

1201.6.14 Elevator Control

Elevator control value = 0

1201.6.15 Means of Egress Emergency Lighting

Means of egress emergency lighting category = Category c

Means of egress emergency lighting value = 4

1201.6.16 Mixed Occupancies

No mixed occupancies

Mixed occupancies value = 0

1201.6.17 Automatic Sprinklers

Automatic sprinklers category = Category c

Automatic sprinklers category value = 0

1201.6.18 Standpipes

Standpipes category = Category b

Standpipes category value = 0

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1201.6.19 Incidental Use Area Protection

Incidental use area protection required = none

Incidental use area protection provided = none

Incidental use area protection value = 0

Modular Building

Summary Evaluation Process			
SAFETY PARAMETERS	FIRE SAFETY (FS)	MEANS OF EGRESS (ME)	GENERAL SAFETY (GS)
1201.6.1 Building Height	1	1	1
1201.6.2 Building Area	2.8	2.8	2.8
1201.6.3 Compartmentation	4	4	4
1201.6.4 Tenant and Dwelling Unit Separation	0	0	0
1201.6.5 Corridors Walls	0	0	0
1201.6.6 Vertical Opening	0	0	0
1201.6.7 HVAC Systems	5	5	5
1201.6.8 Automatic Fire Detection	-4	-4	-4
1201.6.9 Fire Alarm System	0	0	0
1201.6.10 Smoke Control	.....	0	0
1201.6.11 Means of Egress Capacity	.....	2	2
1201.6.12 Dead Ends	.....	2	2
1201.6.13 Maximum Exit Access Travel Distance	.....	3.5	3.5
1201.6.14 Elevator Control	0	0	0
1201.6.15 Means of Egress Emergency Lighting	.....	4	4
1201.6.16 Mixed Occupancies	0	.....	0
1201.6.17 Automatic Sprinklers	0	0	0
1201.6.18 Standpipes	0	.....	0
1201.6.19 Incidental Use Area Protection	0	0	0
Building Score – Total Value	8.8	20.3	20.3

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Mandatory Safety Scores			
Occupancy	FIRE SAFETY (FS)	MEANS OF EGRESS (ME)	GENERAL SAFETY (GS)
Education	29	40	40

Evaluation Formulas		
Formula	Calculations	Pass/Fail
FS – MFS > 0	8.8 – 29 = -20.1	Fail
ME – MME ≥ 0	20.3 – 40 = -19.7	Fail
GS – MGS ≥ 0	20.3 – 40 = -19.7	Fail

Conclusion for Building: The fire safety evaluation of the building indicates that the building is below the mandatory fire safety criteria of Section 1201.6. The evaluation scores can be improved to meet or exceed the mandatory fire safety criteria by adding a sprinkler system and one or more of the following actions for automatic fire detection or fire alarm. Several of these actions under the automatic fire detection or fire alarm may already have been installed during the installation of the classroom since the drawings indicate that several of these fire safety features were to be done by others during the installation of the building.

This evaluation was based on a specific building without any knowledge of its site conditions. The site condition may increase the fire safety by providing a separation between the building and other buildings or property lines. In this evaluation no credit was given for this separation (Section 1201.6.2.1).

This evaluation would not be accurate for a building with a different configuration. A change in the number and layout of the classrooms could affect the building areas, means of egress capacity, and travel distance. A change in any one of these features would change evaluation scores.

Automatic Fire Detection: If smoke detectors indicated on the drawings have been installed, the Automatic Fire Detection Category can be changed from a “Category a” with a value of -4 to a “Category c” or “Category d” or “Category e”. A change to a “Category c” or “Category d” or “Category e” will not increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy, but will increase the evaluation scores.

A “Category c” will require the installation of smoke detectors in the HVAC system to prevent the distribution of smoke within the classroom by the HVAC system. The activation Fire Safety of the smoke detector will shut down the HVAC system and sound an alarm in

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the classroom. The activation of the smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category c” is zero.

A “Category d” will require the installation of smoke detectors in the ceilings of the restroom and closet. The activation of any smoke detectors will sound an alarm in the classroom. The activation of any smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category d” is 4.

A “Category e” will require the installation of smoke detectors in the ceilings of the classroom, restroom, and closet. The activation of any smoke detector will sound an alarm in the classroom. The activation of any smoke detector may also sound an alarm at a central station, if the classroom is part of a larger school facility. The evaluation value of a “Category e” is 8.

Fire Alarm: If the manual fire alarm system indicated on the drawings has been installed, the Fire Alarm Category can be changed from a “Category c” with a value of zero to “Category d” or “Category e”. The change to a “Category e” will not increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy, but will increase the evaluation scores.

A “Category d” will require the installation of a fire alarm in accordance with NFPA 72. Since the classroom is not required by the Florida Building Code to have a manual fire alarm, the installation of the fire alarm will exceed the minimum code requirement. The evaluation value of a “Category d” is 3.

A “Category e” will require the installation of a fire alarm in accordance with NFPA 72 with an emergency voice/alarm communication system and a fire command station to comply with Section 403.8. The evaluation value of a “Category e” is 5.

Automatic Sprinklers: Automatic sprinklers are not required and were not provided so the evaluation category is “Category c”. Changing the “Category c” with a value of zero to “Category f” will not increase the evaluation scores to more than the mandatory safety scores of Section 1201.8 require for Educational Occupancy, but will almost increase the evaluation scores to more than the mandatory safety scores.

A “Category f” will require the installation of a sprinkler system complying with Section 903.3.1.1. The evaluation value of a “Category f” is 18.

Summary: To develop evaluation scores that are equal to or exceed the mandatory safety scores, it will be necessary to install Automatic Sprinklers and either one of the following five modifications:

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Automatic Fire Detection (smoke detectors)

“Category c”

“Category d”

“Category e”

Fire Alarm (manual fire alarm)

“Category d”

“Category e”

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Task 2: *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*: Evaluation using these guidelines requires site specific knowledge of the building. The evaluation under these guidelines will require the computer modeling of a specific building including modeling of the fire, and the occupants. Due the lack of site specific information or data, it is impractical to perform such an analysis at the state level. This evaluation including the perimeters for conducting the evaluation may be done by the authority having jurisdiction for their specific buildings through coordination with a Fire Protection Engineer.