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Sent: Friday, October 23, 2009 1:18 PM
To: structuralsafety@nist.gov
Subject: NISTIR 7636 Comments

Stephen Cauffman,

I took the opportunity to read the 'Draft Report on the Collapse of the Dallas Cowboys Indoor Practice Facility, May 2, 2009' (NISTIR 7636). It is a very impressive report and I enjoyed perusing through it.

After reading the report, I had some thoughts to offer about the contents of the report. Since comments are being solicited, I am sending them to you in an attachment to this email. Some of my thoughts deal with the issue of classification of the structure as 'enclosed' versus 'partially enclosed'. The attached worksheet is included to hopefully support my thoughts.

Please let me know if you have problems opening any of the attachments, or if you have any questions regarding the attachments. I certainly look forward to hearing more about this incident as we are all learning quite a bit because of it.

Best regards,
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COMMENTS ON NISTIR 7636

'DRAFT REPORT ON THE COLLAPSE OF THE DALLAS COWBOYS INDOOR PRACTICE FACILITY, MAY 2, 2009'
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY.

SECTION 4.1.1 DESIGN WIND LOADS

PAGE 41, LAST PARAGRAPH:

"In addition, this structure is flexible and under design wind loading conditions, the structure deforms significantly (see Table 5-3), resulting in substantial distortions to the door framings that can cause the doors to fail to remain closed or latched during a wind storm (see Figure 3-3)."

If it is accepted that the door frames distort enough to fail and/or open, then it would be expected that these distortions would occur to the doors that are located in the walls perpendicular to the direction of the applied wind. Therefore the opening of the doors increases the A_{oi} portion of the formula and thus decreases the A_o / A_{oi} ratio. Hence, the structure classification leans more toward "enclosed" if the side doors are considered open due to distortion, and not toward "partially enclosed" as implied by the report.

PAGE 41, LAST PARAGRAPH:

"Based on the consideration of vent openings and the possibility of additional openings due to the doors, this structure should be considered partially enclosed for the purposes of internal pressure evaluation."

If the analysis is accepted, then this statement is only true for wind applied to the north or south faces (gables). The structure can be considered enclosed for purposes of internal pressure evaluation when the wind load is applied to the east or west faces (sides) of the structure. This is based on an evaluation that considered all logical combinations of vents and doors being open or closed.

PAGE 41-42:

In order to be complete, the report should account for the second part of the ASCE 7 condition for determination of partially enclosed structures; where $A_o > \text{the smaller of } 4 \text{ ft}^2 \text{ or } 0.01 A_g$ AND $A_{oi} / A_{gi} \leq 0.2$. It cannot be determined from the report whether this condition was considered or not.



FIGURE 4-1

PAGE 42, CHART LEGEND

In order for the rollup doors to provide 48 ft² of area as indicated in the Figure's legend, they would have to have dimensions equal to 12' x 4', 10' x 4.8', or possibly 8' x 6'. The picture on page 30 (Figure 3-3) shows that the rollup door is over 1.5 times the height, and about 4 times the width, of the personnel door. A common size for rollup doors in a facility of this type would be more in line with 12' x 14', which would be close to the scale of what is shown in the Figure 4-1. If this is the case, then the opening area for the rollup doors should be shown in the legend as 168 ft², and not 48 ft².

SECTION 4.2.2

PAGE 51, CASE 1

"... the un-braced length is taken to be the larger of the truss panel length or the length between points of cable bracing."

This is true, but only due to the fact that the radius of gyration for a round shape is the same in both the major and minor axis. In an effort to be complete, I believe that this statement should include this information and not leave it to be assumed.

SECTION 5.2

PAGE 68, FIGURE 5-5

From the Figure, it can be seen that the moment at the eave reduces to 0 in less than a panel width. The analysis in the report is conservative as it uses the maximum value at the node point, and does not consider the moment some distance away at the face of the gusset/web member. Given the rapid decrease in the moment, this could have a significant impact on the value used for the moment. In this case, the reduction of the moment will only affect how much over-stressed the member is, and not the fact that it is over-stressed.

SECTION 5.5 ANALYSIS USING ESTIMATED WIND LOADS ON MAY 2, 2009

PAGE 76, SECOND PARAGRAPH

"The directionality factor K_d was set to 1.0, rather than 0.85, because wind loads for a specific wind direction are sought ..."



Section 6.5.4.4 of ASCE7-05 states “The wind directionality factor, K_d , shall be determined from Table 6-4. This factor shall only be applied when used in conjunction with load combinations specified in Sections 2.3 and 2.4. The wording in this section seems to imply that there is no allowance for a different value for K_d due to specific wind direction analysis. Further, none of the values for K_d in Table 6-4 are shown as 1.0.

Section C6.5.4.4 of ASCE7-05 states the factor K_d “... accounts for two effects: (1) The reduced probability of maximum winds coming from any given direction and (2) the reduced probability of the maximum pressure coefficient occurring for any given wind direction.” By using a value of 1.0 for K_d , NIST implies that the maximum wind is applied in the specified direction and that the maximum pressure coefficients are also occurring. This may be conservative in an analysis that is determining the actual conditions that were occurring at the time of the structure’s failure.

PAGE 76, SECOND PARAGRAPH

“Internal pressures were calculated assuming partially enclosed conditions ...”

As noted in the comments for Section 4.1.1, I believe that the structure should be classified as enclosed when considering a wind load that is normal to structure’s ridge line.

SECTION 7.2 NIST RECOMMENDATION

PAGE 86, FIRST RECOMMENDATION

“A review of the state of practice indicates that there is some disparity on this practice among designers and fabricators of this class of structures, as some rely on fabric to provide lateral support to the frames, while others do not.”

The statement, as worded, could be taken to imply that the industry is split somewhat evenly on this practice. It is my experience that a significant majority of engineers in this industry do not use fabric to provide lateral support to the frames.

GENERAL

Not mentioned anywhere within the report, but probably as important as fabric failure, is the fact that the modulus of elasticity of the roof fabric may be too low to provide sufficient support for the steel. Before the fabric can develop sufficient resistance against sideways movement of the steel member, the elongation of the fabric and thus the deflection of the steel member could be such that a P-Delta effect is already occurring.



Enclosure Classification
Dallas Cowboys Indoor Practice Facility

Structure Dimensions (NISTIT 7636)

Height = 66.4 ft (mean roof height)
 Width = 204 ft
 Length = 406 ft
 Roof Slope = 21 degrees

Areas of Structure and Openings By Location (ft²)

	Unit	Wall-N	Wall-E	Wall-S	Wall-W	Roof	
		13,546	26,958	13,546	26,958	88,717	
Roof Vent	16.0	-	-	-	-	64	(4 @ 16 ft ²)
Gable Vent	25.0	250	-	150	-	-	(10, 6 @ 25 ft ² , respectively)
Pers. Doors	24.5	49	123	98	49	-	(2,5,4,2 @ 24.5 ft ² , resp.)
Roll-up Doors	168.0	-	-	336	-	-	(2 @ 168 ft ²)

NOTES:

- Wall-N and Wall-S are gable ends.
- Wall-E and Wall-W are sides.
- Roof Vents are considered open at all times.
- Gable Vents and Doors are either open or closed.



Enclosure Classification
Dallas Cowboys Indoor Practice Facility

Location Desc.	Wall-N							
Roof Vent Open?	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Gable Vent Open	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
Pers. Door Open?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Roll Door Open?	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE
A _o	299.0	49.0	250.0	-	299.0	49.0	250.0	-
A _{oi}	819.5	669.5	550.0	400.0	483.5	333.5	214.0	64.0
A _o / A _{oi}	0.36	0.07	0.45	-	0.62	0.15	1.17	-
Part 1 Satisfied?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
A _g	13,546	13,546	13,546	13,546	13,546	13,546	13,546	13,546
A _{gi}	156,179	156,179	156,179	156,179	156,179	156,179	156,179	156,179
A _{oi} / A _{gi}	0.0052	0.0043	0.0035	0.0026	0.0031	0.0021	0.0014	0.0004
Min(0.01A _g , 4)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
A _o > Min ?	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE
A _{oi} / A _{gi} <= 0.2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Part 2 Satisfied?	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE
Part 1&2 Satisfied ?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

(TRUE = Partially Enclosed, FALSE = Enclosed)

Location Desc.	Wall-E							
Roof Vent Open?	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Gable Vent Open	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
Pers. Door Open?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Roll Door Open?	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE
A _o	122.5	122.5	-	-	122.5	122.5	-	-
A _{oi}	996.0	596.0	800.0	400.0	660.0	260.0	464.0	64.0
A _o / A _{oi}	0.12	0.21	-	-	0.19	0.47	-	-
Part 1 Satisfied?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
A _g	26,958	26,958	26,958	26,958	26,958	26,958	26,958	26,958
A _{gi}	142,766	142,766	142,766	142,766	142,766	142,766	142,766	142,766
A _{oi} / A _{gi}	0.0070	0.0042	0.0056	0.0028	0.0046	0.0018	0.0033	0.0004
Min(0.01A _g , 4)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
A _o > Min ?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
A _{oi} / A _{gi} <= 0.2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Part 2 Satisfied?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Part 1&2 Satisfied ?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

(TRUE = Partially Enclosed, FALSE = Enclosed)



Enclosure Classification
Dallas Cowboys Indoor Practice Facility

Location Desc.	Wall-S							
Roof Vent Open?	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Gable Vent Open	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
Pers. Door Open?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Roll Door Open?	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE
A_o	584.0	434.0	486.0	336.0	248.0	98.0	150.0	-
A_{oi}	534.5	284.5	314.0	64.0	534.5	284.5	314.0	64.0
A_o / A_{oi}	1.09	1.53	1.55	5.25	0.46	0.34	0.48	-
Part 1 Satisfied?	FALSE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE
A_g	13,546	13,546	13,546	13,546	13,546	13,546	13,546	13,546
A_{gi}	156,179	156,179	156,179	156,179	156,179	156,179	156,179	156,179
A_{oi} / A_{gi}	0.0034	0.0018	0.0020	0.0004	0.0034	0.0018	0.0020	0.0004
$\text{Min}(0.01A_g, 4)$	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$A_o > \text{Min} ?$	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
$A_{oi} / A_{gi} \leq 0.2$	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Part 2 Satisfied?	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
Part 1&2 Satisfied ?	FALSE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE

(TRUE = Partially Enclosed, FALSE = Enclosed)

Location Desc.	Wall-W							
Roof Vent Open?	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Gable Vent Open	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
Pers. Door Open?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Roll Door Open?	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE
A_o	49.0	49.0	-	-	49.0	49.0	-	-
A_{oi}	1,069.5	669.5	800.0	400.0	733.5	333.5	464.0	64.0
A_o / A_{oi}	0.05	0.07	-	-	0.07	0.15	-	-
Part 1 Satisfied?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
A_g	26,958	26,958	26,958	26,958	26,958	26,958	26,958	26,958
A_{gi}	142,766	142,766	142,766	142,766	142,766	142,766	142,766	142,766
A_{oi} / A_{gi}	0.0075	0.0047	0.0056	0.0028	0.0051	0.0023	0.0033	0.0004
$\text{Min}(0.01A_g, 4)$	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$A_o > \text{Min} ?$	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
$A_{oi} / A_{gi} \leq 0.2$	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Part 2 Satisfied?	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
Part 1&2 Satisfied ?	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

(TRUE = Partially Enclosed, FALSE = Enclosed)