

INDIAN METAL BUILDING FORUM

IMBF

Connecting India's Metal Building Ecosystem

5C FRAMEWORK: CONNECT • COLLABORATE • CREATE • CONSTRUCT • CERTIFY+

RESOURCE CENTRE

Technical Knowledge Series

STEEL STRUCTURE FAILURE & LESSONS LEARNED

Fabric-Covered Steel Frame Building Collapse: Bracing Assumed from Fabric, Wind below Design Speed

Dallas Cowboys Indoor Practice Facility, Irving, Texas, USA | 2 May 2009

Learn from Failure
Improve the System
Prevent Recurrence

CASE STUDY NO:	IMBF-SF-007
COUNTRY:	United States of America
YEAR:	2009
STRUCTURE TYPE:	Fabric-covered tubular steel frame building (series of identical frames)
TECHNICAL CATEGORY:	Steel building frames / Inadequate bracing / Wind loading

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Rev 00 | 04 October 2026 | Educational / Technical Reference (Research Draft)

IMBF publishes this educational case study. IMBF was not the designer, builder or investigator of the structure.

A DOCUMENT CONTROL AND STATUS

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Technical review status

- ☒ Research Draft (compiled from referenced public sources; not yet reviewed)
- ☐ Technical Review
- ☐ IMBF Approved for Publication

This draft must not be marked approved until an authorised IMBF reviewer has checked it against the primary investigation report listed in the Source Register.

Disclaimer

This document has been prepared by the Indian Metal Building Forum (IMBF) as an educational and technical knowledge resource. The case study is based on publicly available reports, engineering publications, investigation findings and other referenced sources. IMBF has not conducted the original investigation and does not represent this publication as the official investigation report. IMBF was not the manufacturer, designer, contractor or investigator of the structure.

The technical explanations and lessons presented are intended for general educational and professional-development purposes. They shall not be used as a substitute for: project-specific structural design; engineering calculations; site investigation; competent structural-engineering review; statutory approval; manufacturer instructions; applicable codes and standards; independent inspection; accredited testing or certification.

Readers must verify project-specific requirements with qualified professionals and the applicable statutory and code requirements. Where facts are uncertain or disputed, this document identifies them as such.

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How to read the references. Tags such as [S1] point to the Source Register on the last page. Text marked "IMBF interpretation" is engineering commentary by this series and is not a finding of the original investigators.

1 EXECUTIVE SUMMARY

Question	Answer
What happened?	A large fabric-covered steel frame building collapsed during a severe thunderstorm. [S1] [S2]
Where?	Indoor practice facility of a professional football team, Irving, Texas, USA. [S1]
When?	Afternoon of 2 May 2009. [S1]
What structure?	A series of identical tubular steel frames with a tensioned fabric covering, designed and built in 2003. [S1] [S2]
What failed?	The steel frames. Specific members and sequence are in the full report, which was not read for this draft. [S1]
Why?	The structure failed under wind loads well below those required by the design standard. The investigators found three design assumptions that reduced safety: the building was treated as fully enclosed, the fabric was relied on to brace the frames laterally, and local bending in the frame members was not considered. [S2]
Consequence?	12 people injured, one seriously. Total loss of the building. [S1]
Main lesson	A brace must be a structural element that will still be there in the storm. Cladding or fabric that can tear is not a brace.

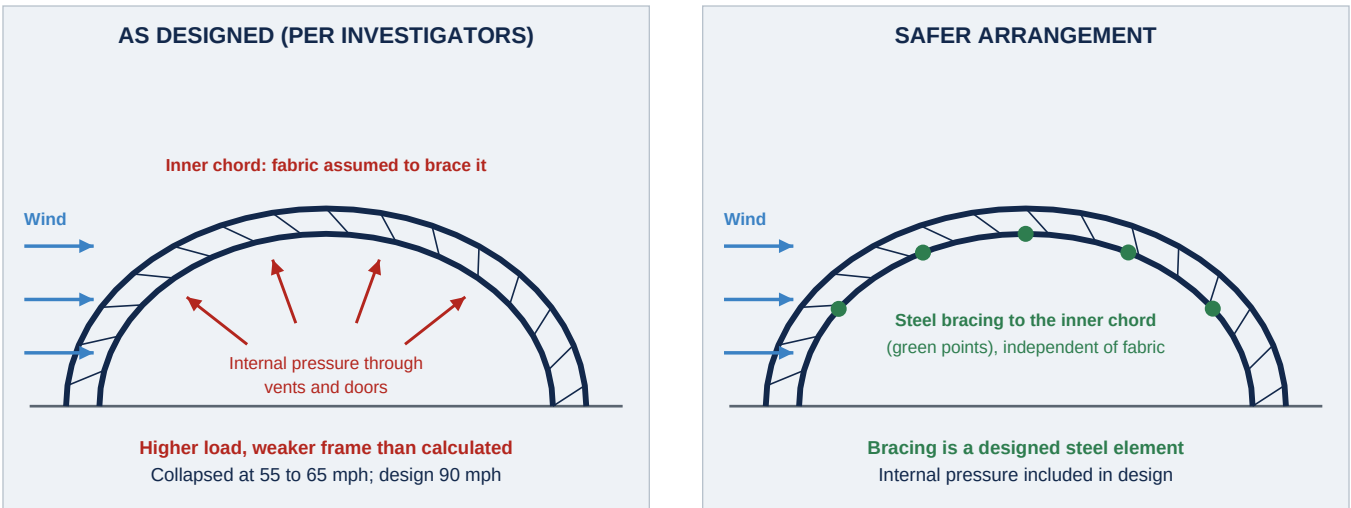


Figure 1. Design assumptions questioned by the investigators, and the safer alternative. Original IMBF schematic; conceptual, not to scale.

2 PROJECT BACKGROUND

Only data found in the consulted sources is listed. Missing data is stated as not established rather than estimated.

Item	Verified data	Source
Purpose	Indoor sports practice facility.	[S1]
Structural system	Series of identical tubular steel frames with a tensioned fabric covering.	[S2]
Built	Designed and constructed in 2003.	[S1]
Design wind speed	90 mph (about 145 km/h), per the national wind load standard.	[S2]
Wind at collapse	Gusts estimated at 55 to 65 mph (about 89 to 105 km/h), perpendicular to the long side; a microburst was centred about one mile (1.6 km) to the south-west.	[S2]
Enclosure classification	Stated as fully enclosed in the design documents; assessed as partially enclosed by the investigators because of vents and multiple doors.	[S2]
Bracing assumption	Design documents stated that the fabric provided lateral bracing to the frames; the investigators did not rely on it.	[S2]
Dimensions, frame spacing, steel grades, member sizes	Not established in the available source. (given in the full report).	-

3 FAILURE TIMELINE

DESIGN	Designed in 2003 with frames checked as fully enclosed, braced by the fabric, and without local bending effects. [S2]
PROCUREMENT	Not established in the available source.
FABRICATION	Not established in the available source.
ERECTION	Constructed in 2003. Erection details: Not established in the available source.
DEFECT / CHANGE	Demand and capacity as calculated by the investigators differed significantly from the original design values. A press summary reports overstress of about 500 %. [S2] [S4]
TRIGGER EVENT	2 May 2009: severe thunderstorm with a nearby microburst; gusts of 55 to 65 mph on the long side. [S2]
LOCAL FAILURE	Frame members failed under combined external and internal wind pressure. Member and location: Not established in the available source.
PROGRESSIVE FAILURE	Failure of one or a few frame members can propagate through such a structure; the investigators list this as a point to evaluate in similar buildings. [S2]
COLLAPSE	Total collapse; 12 injured. [S1]
INVESTIGATION	NIST reconnaissance team on site from 12 May 2009; draft report 6 October 2009; final report NISTIR 7661 on 26 January 2010. [S1] [S2]
CORRECTIVE ACTION	NIST recommended that other fabric-covered frame structures be evaluated and worked with code bodies on changes to standards. [S2]

4 WHAT FAILED?

Element	Identification
Primary failed component	Tubular steel frames of the building. [S1]
Secondary failed components	Fabric covering and remaining frames.
Connection involved	Member connections: Not established in the available source.
Load path involved	Wind on fabric -> frames (outer and inner chords and web members) -> foundations.
Failure mode	Overstress and buckling of frame members under wind, without effective lateral bracing; progressive collapse. Detailed mode: see full report. [S2]

5 ENGINEERING FAILURE MECHANISM

Internal pressure. Openings such as vents and doors let wind pressurise the inside of a building. Added to suction outside, this raises the net load on the frames. Treating the building as fully enclosed left this out. [S2]

Bracing by fabric. A compression chord needs lateral restraint at close spacing. The design counted on the fabric for this. Fabric can tear or go slack, and then the unbraced length, and the buckling load, change at once. [S2]

Local bending. Loads applied between panel points bend the chord locally, in addition to its axial force. The design documents did not show this was considered. [S2]

Result. With all three included, the investigators found that the structure could not carry even moderate wind, which matches collapse at 55 to 65 mph against a 90 mph design speed. [S2]

Mechanism considered	Role in this case
Wind loading	Trigger, well below design level (reported). [S2]
Bracing failure / inadequate lateral restraint	Underlying cause (reported). [S2]
Member buckling and bending	Member-level mode (reported in general terms). [S2]
Progressive collapse	Identified as a risk for this structure type (reported). [S2]
Snow, ponding, corrosion, fatigue	Not reported as factors.

6 ROOT-CAUSE ANALYSIS

Area	Finding	Basis
Design	Enclosure classification, bracing assumption and omission of local bending led to underestimated demand and overestimated capacity.	Reported [S2]
Material	Not established in the available source.	-
Fabrication	Not established in the available source.	-
Welding	Not established in the available source.	-
Bolting	Not established in the available source.	-
Erection	Not established in the available source.	-
QA/QC	Design assumptions were not challenged by an independent check before construction or during six years of service.	IMBF interpretation
Operation	In use during a severe thunderstorm.	Reported [S1]
Maintenance	Not established in the available source.	-
Management / communication	Proprietary building system; reliance on the supplier design.	IMBF interpretation

Level	Statement
Immediate cause	Frame members overstressed by wind pressure during a thunderstorm. [S2]
Contributing causes	Internal pressure not included; fabric counted as bracing; local bending not included. [S2]

Level	Statement
Root cause	Unconservative design assumptions for a proprietary system were accepted without independent verification. (IMBF interpretation of [S2])

7 FIVE-WHY ANALYSIS

IMBF interpretation built on the findings reported in the cited sources.

WHY 1	Why did the building fall? Because its frames could not resist the wind on that day.
WHY 2	Why not, when the wind was below design speed? Because real demand was higher and real capacity lower than the design had calculated.
WHY 3	Why was the calculation wrong? Because it assumed a fully enclosed building, bracing from the fabric, and no local bending.
WHY 4	Why were these assumptions made? Because they made a light, economical frame work on paper.
WHY 5	Why were they not caught? Because no independent engineer tested them against the actual openings and the behaviour of fabric.
ROOT SYSTEMIC / CAUSE	Reliance on a supplier design for a non-standard structure without independent review.

8 CORRECTIVE ACTION

Immediate corrective action (as reported)

- Federal investigation with site survey, wind-field reconstruction and structural analysis of a typical frame. [S1] [S2]
- Recommendation that owners of similar fabric-covered frame buildings have them evaluated. [S2]
- Rebuilding of the facility: Not established in the available source.

Permanent corrective action (engineering remedy, IMBF interpretation)

- Brace compression chords with steel members designed for the brace force; do not count on fabric or sheeting unless it is designed and detailed as a diaphragm.
- Classify enclosure from the real openings, and design for the resulting internal pressure.
- Include bending from loads between panel points in member checks.
- Check that failure of one frame does not bring down the row.

9 PREVENTIVE ACTION (CAPA)

Problem	Root cause	Corrective action	Preventive action	Responsible party
Frames overstressed	Demand underestimated	Re-analyse and strengthen	Independent design check of proprietary buildings	Owner; reviewing engineer
No effective bracing	Fabric assumed as brace	Add steel bracing	Rule: bracing must be a designed structural element	Structural designer
Internal pressure ignored	Wrong enclosure class	Re-classify; redesign	Opening schedule checked against wind design	Designer; architect
Local bending ignored	Incomplete member check	Add to design	Design checklist for truss chords with distributed load	Structural designer
Whole row can fall	No robustness check	Add longitudinal ties and bracing bays	Robustness check in design review	Structural designer

10

QA/QC FAILURE ANALYSIS: WHAT SHOULD QA/QC HAVE DETECTED?

Original QA/QC records are not available in the consulted sources. The table shows what a robust system should check on a similar structure (IMBF interpretation).

QA/QC area	Check relevant to this type of failure
Material certificates	Grades on certificates match the design assumption.
Traceability	Members, bolts and anchors traceable to their position.
WPS / PQR and welder qualification	Qualified procedures and welders for load-path welds.
Welding inspection and NDT	Critical welds inspected and tested to the specified extent.
Bolt certificates and installation	Bolts, nuts, washers and anchors as specified; tightening recorded.
Dimensional inspection and alignment	Geometry, plumb and level within tolerance; deviations reported to the designer.
Bracing	All permanent and temporary bracing installed and connected before load is applied.
Coating	Protection complete; connections still inspectable.
Drainage	Roof falls, drains and overflows as designed and working.
Erection sequence	Work follows the approved sequence; changes approved in writing.
As-built verification	As-built condition compared with design assumptions and recorded.

11

IMBF OPTIMIZATION STRATEGY

Area	Optimisation
Design	List bracing and enclosure assumptions on the drawings; never use cladding as bracing without a diaphragm design.
Fabrication	Flag critical members and connections on shop drawings; raise a query for anything unclear.
QA/QC	Add hold points for the items that govern stability and load path to the Inspection and Test Plan.
Erection	Follow a written erection sequence with temporary stability designed by an engineer.
Digital traceability	Link inspection records, changes and approvals to each member in the model.
Inspection	Risk-based plan: non-redundant members and connections get the most attention.
Maintenance	Give the owner an inspection and maintenance manual naming the critical items.
Cost	The cost of a check, a brace or an extra bolt is small against the cost of a collapse.
Safety	Occupied long-span light structures get an independent check and a storm procedure.
Productivity	Standard, pre-checked details reduce redesign, site improvisation and rework.

12

DIGITALIZATION

- QR code or barcode on main members linking to drawings, certificates and inspection records.
- Heat-number and lot traceability for steel, bolts and anchors.
- Mobile inspection checklists with photographs at each hold point.
- Changes, queries and approvals logged in a shared cloud record.
- Digital as-built model handed to the owner for inspection and maintenance.

DESIGN

Assumptions, critical items and limits recorded in the model.

FABRICATION

Parts marked and traced; changes raised formally.

INSPECTION

Checklist and photo evidence at hold points.

DISPATCH	Scan-out against the erection sequence.
ERECTION	Scan-in; stability and connection completion recorded.
FINAL INSPECTION	As-built condition verified against design assumptions.
DIGITAL AS-BUILT / RECORD	Handed to the owner with operating limits and inspection schedule.

13

INDIAN CONTEXT: WHAT SHOULD INDIA LEARN FROM THIS FAILURE?

- PEB design depends on flange braces, purlins, girts and rod or cable bracing. If sheeting is assumed to restrain members, that must be justified and the fixings designed for it.
- Buildings with large sliding doors, ridge vents and louvres are common. Their enclosure classification under the wind code must reflect how they are used, including doors left open.
- Fabric and tensile structures, hangars and temporary event structures are growing in use and often come as supplier-designed systems. Owners should commission an independent check.
- Cyclones and thunderstorm gusts produce high local wind speeds. A structure that fails below design speed has a design problem, not a weather problem.
- Proof-checking by a third party is good practice for any non-standard steel building.

Reference	Subject	Relevance to this case
IS 800	General construction in steel: code of practice	Member, connection and stability design.
IS 875 (Part 3)	Wind loads	Design wind speed, pressure coefficients and internal pressure for buildings with openings.
IS 2062	Hot-rolled structural steel	Material conformity.
Project specification and ITP	Contract documents	Where responsibilities, hold points and limits must be written.

Clause numbers are deliberately not cited. Standard titles and current editions must be confirmed against Bureau of Indian Standards publications at technical review.

14

IMBF PREVENTION CHECKLIST

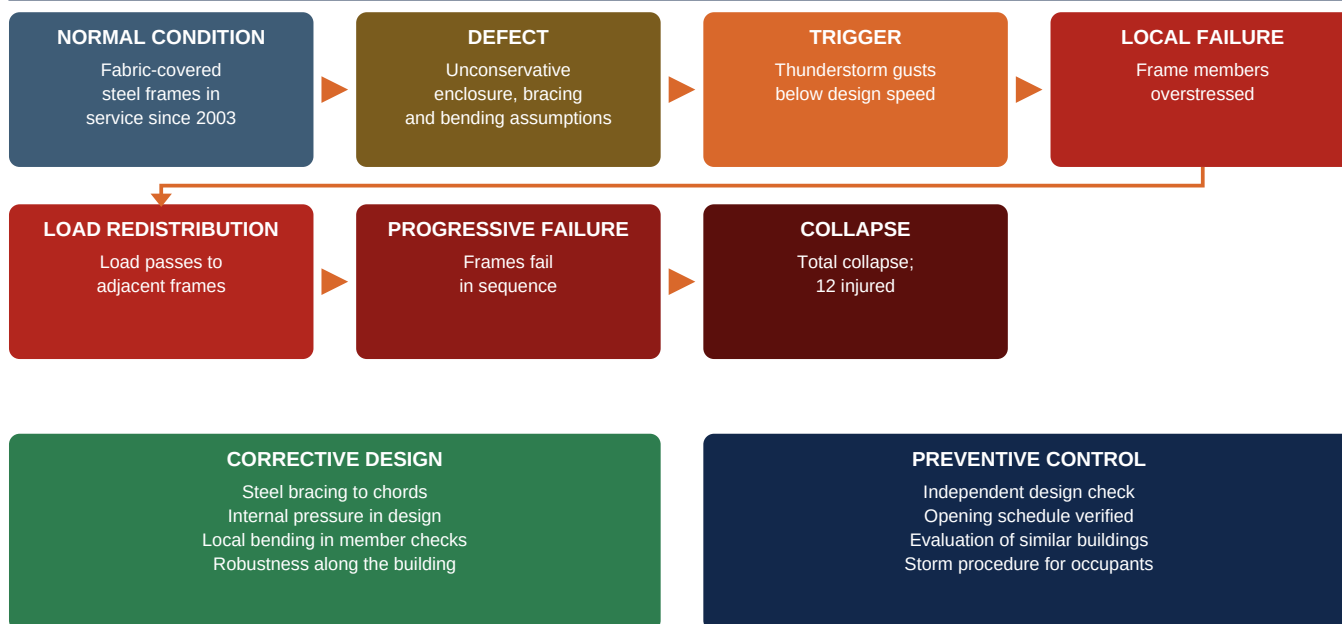
Inspection point	Required check	Status	Remarks
Design review	Enclosure class matches real openings; independent check done	☐	
Connection review	Critical connections designed for real forces	☐	
Material traceability	Certificates on file; items traced to position	☐	
Welding	Qualified WPS and welders	☐	
NDT	Critical welds tested	☐	
Bolting	Bolts and anchors as specified; tightening recorded	☐	
Dimensional inspection	Geometry within tolerance	☐	
Bracing	Every compression chord and flange braced by designed steel members; no reliance on fabric or sheeting unless designed	☐	
Erection sequence	Approved sequence followed; temporary stability checked	☐	
Coating	Protection complete	☐	
Drainage	Drains and overflows clear and working	☐	
Final inspection	Open findings closed before handover	☐	
As-built documentation	As-built records and maintenance manual handed to owner	☐	

15 PHOTOGRAPHS

No third-party photograph is reproduced in this document. Published photographs and report figures exist, but their copyright and publication permission were not established for this series, so they are not used. All figures here are original IMBF schematics.

Photo source	Copyright	License	Permission
None reproduced	Not applicable	Not applicable	Not applicable

16 ORIGINAL IMBF FAILURE DIAGRAM



Original IMBF schematic. Conceptual, not to scale.

17 LESSONS LEARNED

5 engineering lessons

1. Cladding that can tear is not bracing.
2. Internal pressure depends on real openings.
3. Include local bending in chord design.
4. Check buckling with the true unbraced length.
5. Provide robustness along a row of frames.

5 management lessons

1. Commission independent checks of supplier designs.
2. Ask what each design assumption relies on.
3. Act on findings from similar failures.
4. Plan for storms when the building is occupied.
5. Value robustness over minimum weight.

5 QA/QC lessons

1. Verify bracing shown on drawings is installed.
2. Compare openings as built with the design.
3. Keep design calculations with the building file.
4. Inspect fabric tension and fixings.
5. Review the structure when openings are altered.

5 preventive actions

1. Audit existing fabric-covered frame buildings.
2. Add a bracing schedule to drawings.
3. Record enclosure class on the general arrangement.
4. Train designers on internal pressure.
5. Share this case with PEB and tensile-structure suppliers.

18 IMBF KEY MESSAGE

"This building did not meet a storm stronger than its design. It met a moderate wind with braces that existed only as an assumption. Bracing and enclosure assumptions must be real, drawn, built and independently checked."

19 SOURCE REGISTER

Ref	Source and organisation	Date	Used for	Consulted?
S1	Final Report on the Collapse of the Dallas Cowboys Indoor Practice Facility, May 2, 2009. NIST IR 7661. J. L. Gross, J. A. Main, L. T. Phan, F. H. Sadek, S. A. Cauffman, D. P. Jorgensen. National Institute of Standards and Technology. DOI 10.6028/NIST.IR.7661 https://www.nist.gov/publications/final-report-collapse-dallas-cowboys-indoor-practice-facility-may-2-2009	Jan 2010	Event, structure type, injuries, investigation scope	Abstract and project page only
S2	NIST Releases Final Report on Cowboys Facility Collapse. NIST news release. https://www.nist.gov/news-events/news/2010/01/nist-releases-final-report-cowboys-facility-collapse	26 Jan 2010	Principal findings, wind speeds, design assumptions, recommendations	Yes, in full
S3	Dallas Cowboys Practice Facility 2009. NIST disaster and failure studies page. https://www.nist.gov/el/disasterstudies/weather/dallas_cowboys_facility_2009.cfm	2011	Reconnaissance date and study objectives	Yes
S4	NIST recommends code changes for fabric-covered steel structures. Engineering News-Record.	2010	Reported level of overstress	Search extract only

Limits of this draft: the full NIST report [S1] was not read; findings are taken from the NIST news release and project page. Dimensions, member details and the collapse sequence are in the report and are marked as not established here. Speeds were converted to km/h by IMBF and rounded.

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