

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

Steel Column and Beam Collapse during Erection: Two-Bolt Base and Repaired Anchor Bolts Pulled Out

Steel erection site, Byhalia, Mississippi, USA | October 1992

Learn from Failure
Improve the System
Prevent Recurrence

CASE STUDY NO:	IMBF-SF-009
COUNTRY:	United States of America
YEAR:	1992
STRUCTURE TYPE:	Steel columns and a long-span beam during erection
TECHNICAL CATEGORY:	Base plates and anchor rods / Steel-to-foundation interface / Erection stability

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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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Subject	Column and beam collapse during steel erection after anchor bolt pull-out, Byhalia, Mississippi, USA, October 1992

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.

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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 long beam and its two supporting columns fell over just after the crane was released. [S1]
Where?	A steel erection site at Byhalia, Mississippi, USA. [S1]
When?	October 1992; the government inspection was opened on 19 October 1992. Exact date and time: Not established in the available source. [S1]
What structure?	Steel columns 9.8 m (32 ft) tall, each bolted to its footing with two anchor bolts, carrying a 21 m (70 ft) bridge beam. [S1]
What failed?	The anchorage of one column: two anchor bolts pulled out of the concrete footing. [S1]
Why?	The columns had only two anchor bolts each, and the two that pulled out had been damaged and replaced several days earlier. [S1]
Consequence?	One worker killed and one hospitalised with a fracture; both were on the beam when it fell. [S1]
Main lesson	Until the frame is braced, the anchor rods are the only thing holding a column up. Four rods, sound concrete and engineer-approved repairs are the minimum.

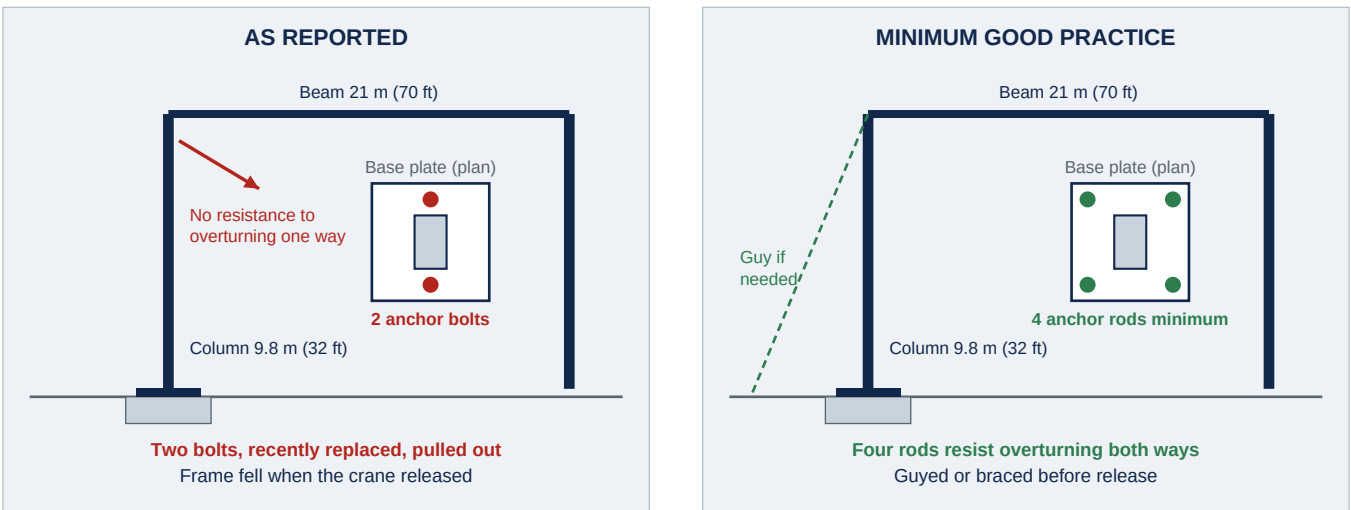


Figure 1. Column base as reported and the present-day minimum for erection stability. Original IMBF schematic; conceptual, not to scale.

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
Work in progress	Erection of structural steel.	[S1]
Columns	Several columns 9.8 m (32 ft) tall, erected and bolted to the footings with two anchor bolts each.	[S1]
Beam	21 m (70 ft) bridge beam secured to the tops of two columns.	[S1]
Anchor bolts	Two bolts at one column had been damaged and replaced several days before.	[S1]
Stage at failure	Crane slings had just been released from the beam.	[S1]
Regulatory record	Accident inspection, four violations recorded.	[S1]
Building type, bolt size and embedment, repair method, concrete strength, bracing or guying	Not established in the available source.	-

3 FAILURE TIMELINE

DESIGN	Column bases detailed with two anchor bolts. Designer intent for erection stability: Not established in the available source.
PROCUREMENT	Not established in the available source.
FABRICATION	Not established in the available source.
ERECTION	Columns stood on two-bolt bases; a 21 m beam lifted onto two of them and connected. [S1]
DEFECT / CHANGE	Two anchor bolts at one column had been damaged and were replaced several days earlier. Method and approval: Not established in the available source. [S1]
TRIGGER EVENT	Crane slings released; the frame now relied on the column bases alone. [S1]
LOCAL FAILURE	The two replaced anchor bolts pulled out of the concrete footing. [S1]
PROGRESSIVE FAILURE	The beam and both columns began to fall away from the crane. [S1]
COLLAPSE	Beam and columns fell to the floor slab; the beam turned over. One killed, one injured. [S1]
INVESTIGATION	Government occupational-safety accident inspection; case closed March 1993. [S1]
CORRECTIVE ACTION	Corrective actions on that site: Not established in the available source. Present US steel erection rules require at least four anchor rods per column and written notice of any anchor rod repair. [S2]

4 WHAT FAILED?

Element	Identification
Primary failed component	Anchor bolts of one column: pull-out from the concrete footing. [S1]
Secondary failed components	The column, the connected beam and the second column.
Connection involved	Column base plate to footing (two anchor bolts).
Load path involved	Beam and worker loads -> column -> base plate -> anchor bolts -> footing.
Failure mode	Anchor pull-out (bond or concrete failure of replaced bolts), then overturning of an unbraced column-beam frame. Exact pull-out mode: Not established in the available source.

5 ENGINEERING FAILURE MECHANISM

Two bolts give one line of resistance. Two anchor bolts on one axis can resist overturning across that axis only by the small width of the base plate. In the other direction the base acts almost as a hinge.

Erection loads are sideways loads. Releasing slings, connectors moving on the beam, out-of-plumb and wind all push the top of a column sideways. Before bracing is in, the base must resist this alone.

Repaired anchors. A bolt re-set in drilled holes or in fresh grout has the strength of that repair, not of the original cast-in bolt. If the repair has not cured, or was not designed, it can pull out at a small load. Here the two bolts that pulled out were the replaced ones. [S1]

No second line. No guys or bracing are reported. When the base let go, nothing else held the frame. [S1]

Mechanism considered	Role in this case
Anchor rod pull-out	Initiating failure (reported). [S1]
Erection instability	Unbraced columns relying on bases (reported). [S1]
Progressive collapse	Beam and second column followed (reported). [S1]
Base plate bending, weld failure, bolt fracture	Not reported.
Corrosion, fatigue, wind	Not reported as factors.

6 ROOT-CAUSE ANALYSIS

Area	Finding	Basis
Design	Two-bolt column base gave little resistance to overturning during erection.	Reported [S1]; IMBF interpretation
Material	Anchor bolt and concrete properties: Not established in the available source.	-
Fabrication	Not established in the available source.	-
Welding	Not established in the available source.	-
Bolting	Replaced anchor bolts pulled out of the footing.	Reported [S1]
Erection	Crane released while the frame depended on bases alone; no guying or bracing reported.	Reported [S1]
QA/QC	No record that the anchor repair was checked or approved before loading.	IMBF interpretation
Operation	Not applicable (under construction).	-
Maintenance	Not applicable.	-
Management / communication	Communication of the anchor repair to the erector and engineer: Not established in the available source.	-

Level	Statement
Immediate cause	Pull-out of two anchor bolts at one column base. [S1]
Contributing causes	Only two anchor bolts per column; bolts recently replaced after damage; frame not braced or guyed when the crane released. [S1]

Level	Statement
Root cause	Column stability during erection depended on an anchorage that was minimal by design and had been repaired without proven capacity. (IMBF interpretation of [S1])

7 FIVE-WHY ANALYSIS

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

WHY 1	Why did the beam and columns fall? Because one column base let go.
WHY 2	Why did it let go? Because its two anchor bolts pulled out of the footing.
WHY 3	Why did they pull out? Because they had been damaged and replaced a few days before, and the repair did not have the needed capacity.
WHY 4	Why was the frame relying on them? Because each column had only two bolts and no guys or bracing were in place when the crane released.
WHY 5	Why was that accepted? Because the base detail and the repair were not assessed for erection stability.
ROOT SYSTEMIC / CAUSE	No requirement at that site for an erection-stable base, an approved anchor repair and a stability check before release.

8 CORRECTIVE ACTION

Immediate corrective action (as reported)

- Government accident inspection of the site. [S1]
- Actions taken by the parties: Not established in the available source.

Permanent corrective action (engineering remedy, IMBF interpretation)

- Provide at least four anchor rods per column, arranged to resist overturning in both directions.
- Design the base, rods and footing for a defined erection load at the top of the column.
- Any damaged, bent, cut or misplaced anchor rod is repaired only to an engineer's written detail, with curing time and, where needed, a proof test.
- Guy or brace columns until the permanent bracing is connected; keep the crane hooked until then.

9 PREVENTIVE ACTION (CAPA)

Problem	Root cause	Corrective action	Preventive action	Responsible party
Anchor bolts pulled out	Unverified repair of damaged bolts	Engineered repair; proof test	Written approval of every anchor rod repair before erection	Engineer of record; main contractor
Base weak in overturning	Two-bolt base	Four-rod base	Minimum four anchor rods; erection load case in base design	Structural designer
Frame unbraced at release	No temporary stability	Guy or brace	Erection scheme: do not release until stable	Erector
Erector unaware of repair	No formal notice	Notify in writing	Handover certificate for foundations and anchors, listing repairs and concrete strength	Main contractor
Workers on unstable steel	Access before stability	Keep off until stable	Pre-climb stability check by a competent person	Erector; site supervisor

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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	Anchor rod grade, diameter, embedment, projection and position surveyed before erection; damaged rods reported, not bent back.
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	Foundation handover certificate with concrete strength and a list of any anchor repairs, approved by the engineer.

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IMBF OPTIMIZATION STRATEGY

Area	Optimisation
Design	Four-rod bases as standard; base and footing checked for an erection load at column top.
Fabrication	Flag critical members and connections on shop drawings; raise a query for anything unclear.
QA/QC	Anchor survey and foundation handover as a hold point before the first column is lifted.
Erection	No column left free-standing on anchors alone beyond the erection scheme; guys until bracing is in.
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	Higher review level where people work under or occupy the structure.
Productivity	Standard, pre-checked details reduce redesign, site improvisation and rework.

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DIGITALIZATION

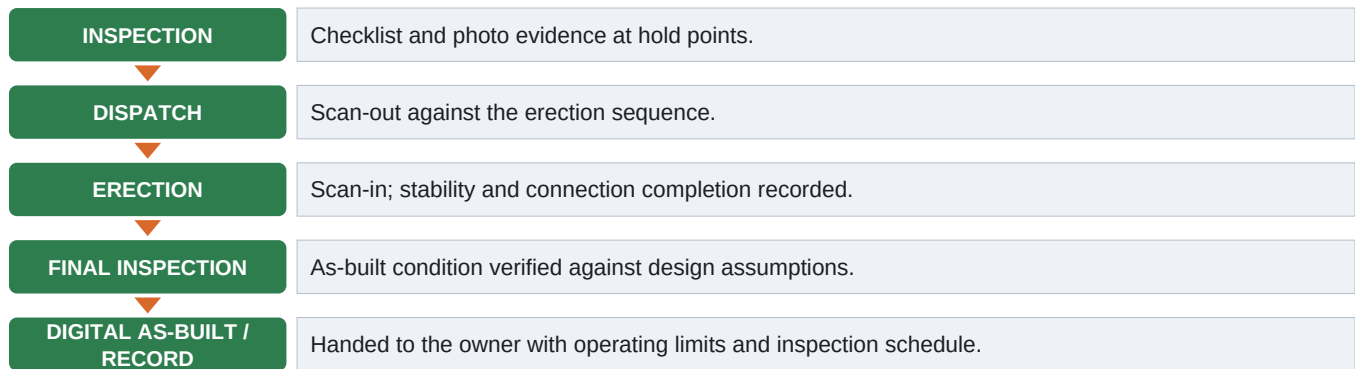
- Anchor bolt survey recorded digitally with photographs and linked to each column mark.
- Foundation handover certificate and repair approvals stored against the grid location.
- QR code or barcode on main members linking to drawings, certificates and inspection records.
- Heat-number and lot traceability for steel, bolts and anchors.
- Mobile inspection checklists with photographs at each hold point.

DESIGN

Assumptions, critical items and limits recorded in the model.

FABRICATION

Parts marked and traced; changes raised formally.



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INDIAN CONTEXT: WHAT SHOULD INDIA LEARN FROM THIS FAILURE?

- Misplaced, bent, short or damaged anchor bolts are among the most common site problems in PEB and structural steel jobs in India.
- Common site fixes, such as heating and bending bolts, welding extensions, enlarging base plate holes or chemical anchors, change the capacity and need the designer's approval.
- Civil work and steel erection are usually by different agencies. A formal handover of foundations, with survey, concrete strength and repair list, closes the gap.
- PEB columns with pinned bases often have light anchorage. Erection manuals require temporary guying or a braced bay first; this must be enforced.
- Grouting under base plates should not be delayed where the design relies on it, and columns should not be loaded on levelling nuts beyond what the rods can carry.

Reference	Subject	Relevance to this case
IS 800	General construction in steel: code of practice	Member, connection and stability design.
IS 5624	Foundation bolts	Product requirements for foundation (anchor) bolts.
IS 456	Plain and reinforced concrete	Anchorage in concrete footings and concrete strength.
IS 7205 and IS 12843	Erection safety and erection tolerances	Safe erection and tolerance on anchor position.
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

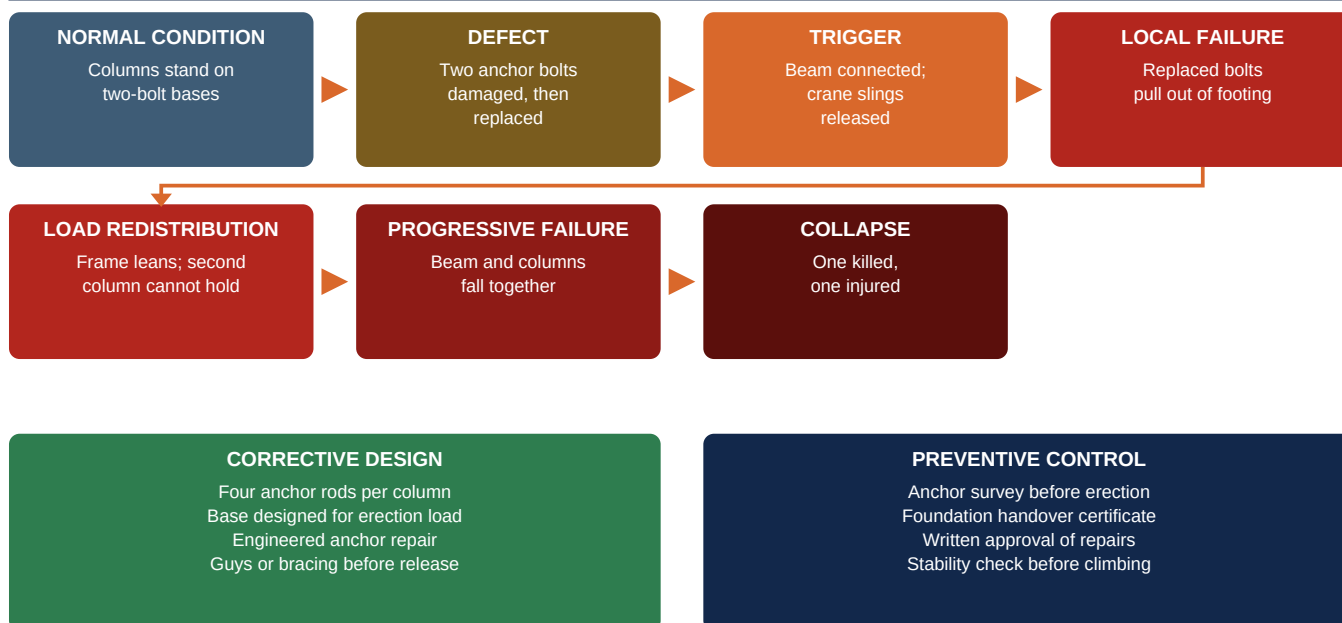
Inspection point	Required check	Status	Remarks
Design review	Design assumptions listed and independently checked	☐	
Connection review	Critical connections designed for real forces	☐	
Material traceability	Certificates on file; items traced to position	☐	
Welding	Qualified WPS and welders	☐	
NDT	Critical welds tested	☐	
Bolting	Anchor rods: number (four minimum), size, embedment, projection and position verified; repairs approved in writing	☐	
Dimensional inspection	Geometry within tolerance	☐	
Bracing	All bracing installed and connected	☐	
Erection sequence	Columns guyed or braced before crane release; foundation handover accepted	☐	
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.

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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. Anchor rods carry the erection case.
2. Two rods on one line do not resist overturning.
3. A repaired anchor has only the capacity of the repair.
4. Unbraced frames need guys.
5. Footing concrete and embedment govern pull-out.

5 management lessons

1. Hand over foundations formally.
2. Tell the erector about every repair in writing.
3. Give the erector authority to refuse unsafe bases.
4. Coordinate civil and steel contractors.
5. Plan erection around stability, not crane time.

5 QA/QC lessons

1. Survey anchors before erection.
2. Record and report every damaged rod.
3. Check concrete strength before loading.
4. Verify repairs by inspection or proof test.
5. Do not accept site-bent or welded rods without approval.

5 preventive actions

1. Standardise four-rod bases.
2. Use anchor templates when casting.
3. Protect projecting rods from site traffic.
4. Include base stability in the erection scheme.
5. Share this case with erection crews.

18 IMBF KEY MESSAGE

"A steel frame starts at the anchor rods. Two rods, one of them a doubtful repair, held up a 21-metre beam with men on it. Count the rods, check the concrete, approve every repair, and brace before you release."

19 SOURCE REGISTER

Ref	Source and organisation	Date	Used for	Consulted?
S1	Accident Report Detail, Accident Summary No. 603381, and Inspection No. 1683465. US Occupational Safety and Health Administration (OSHA). https://www.osha.gov/ords/imis/accidentsearch.accident_detail?id=603381	Inspection opened 19 Oct 1992	All facts of the event	Yes (summary record)
S2	Anchor bolt failure and column collapse: one of the "deadly dozen" hazards; and Near misses in three column collapses attributed to anchor bolt failure. Ironworker Management Progressive Action Cooperative Trust (IMPACT), quoting OSHA standard 1926.755. https://impact-net.org/news/2013/05/06/near-misses-in-three-column-collapses-attributed-to-anchor-bolt-failure-and	2012; 2013	Present-day minimum of four anchor rods; notice of repairs; recurring nature of the hazard	Search extracts only

Limits of this draft: the only source for the event is a short government accident summary. It gives no bolt sizes, repair method, concrete data or building type, and these are marked as not established. The mechanism section is general engineering explanation, not a finding of the inspection. The OSHA rule text in [S2] should be checked against the regulation itself.

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