Prestress Inspection

2025

**TECHNICAL TRAINING AND
CERTIFICATION PROGRAM**

IOWA | DOT

TECHNICAL TRAINING AND CERTIFICATION PROGRAM
CONTACT INFORMATION

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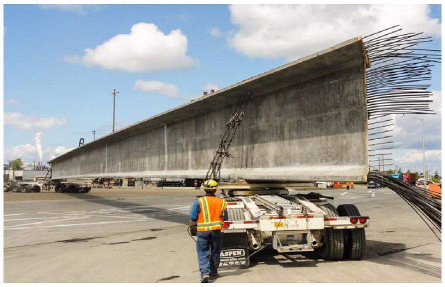
SAFETY



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SAFETY AT THE PLANT

Many safety hazards associated with beam fabrication:

- Overhead hazards
- Stressing/detensioning hazards
- Pinch points
- Heat/cold hazards
- Moving equipment/vehicles

2

3

SAFETY

- The fabricator shall have a safety policy, safety program, safety manual and a designated safety officer responsible for enforcing the safety rules.
- The fabricator shall make adequate provisions satisfactory to the DME for the safety of the inspector, particularly at all sampling, tensioning and inspection locations.
- Any violation of the Safety Laws, Rules or Regulations may be considered sufficient grounds by the DME for suspending all inspection activities.

4

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FABRICATOR SAFETY PROGRAM

- Component of Approved QC Plan
- Details the Producers commitment to Safety
- Identifies the Safety Program and the Safety Officer
- Details the Safety Training and the policies

6

F.O.E.S.

- Falling
- Overhead
- Ears/Eyes
- Shoes

7

SAFETY

- TORNADO DRILLS
- The DOT Inspector should also participate

8

9

Approved Producers
Acceptance &
Certified Technicians

1

Approved Producers

- Fabricator must be on approved list to supply units to Iowa DOT administered projects

- Why have Approved Producers??
  - To ensure that all work will be in accordances with the contract documents by establishing management commitment to Quality Control, with trained, qualified, certified personnel and uniform production procedures.
  - Also applies to Local Agency Federal Aid Projects
  - Must be approved prior the letting

2

Approved Producers

- Approved producers list is in Maple

- What needs to be done by the fabricator to become an approved producer?
  - Must submit application. (I.M. 570 page 21 of this manual)
  - Must submit Quality Control Manual

3

- Submit to the respective District Materials Engineer (DME)
- Fabricators with operations in more than one District shall apply to the appropriate DME for each site

4

Acceptance

- Final Inspection and Quality Assurance of the units at the production facility lies with the District Materials Engineer or their representative.
- Acceptance of products for incorporation into the project is the responsibility of the contracting authority (project personnel)
- Job site personnel should be inspecting each unit for possible shipping damage and to ensure that proper identification and required reports have been received
- Damage observed at the job site should be reported to the DME responsible for the project's materials administration

5

Certified Technicians

- Iowa Level I PCC or Level I ACI Technicians
- Personnel sampling or performing aggregate tests must have appropriate Iowa Aggregate Certification
- Prestress School
  - Must attend and pass
  - 40 hours experience over 2 years
    - Document and turn into your DOT Inspector (I.M. 570 page 22)
  - Renewal will be required every 5 years

6

Quality Control Plans

QUALITY CONTROL

1

Quality Control Manual

- Each Fabricator/Producer shall have a plant specific Quality Control Manual.
- Submit Application and QC Manual
  - Submitted to appropriate District Materials Engineer & To the Prestress & Precast Concrete Engineer (Mahbub Khoda)
- IM 570 Appendix F of this manual
  - Principal Factors in Quality Control

2

Quality Control Manual

- Management Commitment to Quality
- Details standard Operating Procedures for Production Plant
- Safety Commitment and Safety Program
- Qualified personnel for all stages of fabrication
- Testing and control of materials

3

Quality Control Manual

- Identifies where Documentation is kept and for how long.
- Tensioning Procedures
- Concrete Mix Designs
- Curing and Finishing Procedures
- A Sample of the Forms they will be using

4

Quality Control Manual

- Documentation, file management and record keeping
- Repair Procedures
- Dispute resolution process
- Storage and Shipping Details

5

Quality Control Manual

- Flowchart listing the Chain of Command
  - Do not want just the name of the position, want the names of the people typed in as well.
- QC Inspection done by QC or by other than those responsible for production and thus reporting directly to management.

6

Quality Control Manual

- Producers expected to abide by all aspects of QC Plan
- Iowa DOT Inspectors (QA) monitors the producer for compliance with QC Plan
- Failure to comply can result in actions against producer
- The Fabricator shall submit an updated Manual every other calendar year and must be submitted by no later than January 31st or the Fabricator may be taken off approved list

7

Quality Control Inspection (QC)

- Producer's Inspectors perform Quality Control (QC) inspection duties:
  - Inspect all phases of all production
  - Actively corrects any deficiencies noted
  - Completes all documentation for production cycles
  - Maintains official production files

8

Quality Assurance Inspection (QA)

- IDOT's Inspectors perform Quality Assurance (QA) inspection Duties:
  - Periodically Monitors all phases of Production
  - Notifies Producer QC Staff to correct any deficiencies
  - Reviews Documentation for production cycles
  - Issues Certified Report for finished Items (905)

9

Quality Control Manual

- Any Questions ? ? ? ?

10

Prefabrication
&
Materials

1

Prefabrication Meetings

- Fabricator initiates the meeting prior any Fabrication
- Both Representatives from Fabricating Plant and DOT shall attend
- Periodic scheduled meetings between Fabricator and District Materials Staff may be used in lieu of the Prefab Meeting

2

Prefabrication Meetings

- Production Schedule
- Changes to Specs, I.M.'s, Shop Drawings
  - If something changes in the Plans
- Mix Designs
- Any of the Testing
- Material Storage and Handling
- Final Inspection
- Anything that is a Concern
- Good time to bring up and Ongoing Issues

3

Materials

- Maple
- Approved Sources/Brands
  - Approved Sources: Where the materials is being produced
  - Approved Brand: The name of the material being used

4

Aggregates

- Spec Article 2407.02.A1
- Certified by truck ticket from an approved supplier per IM 209 & T203
- Individual aggregates are to be sampled and tested to ensure gradation compliance
- Based on "lot" system 1 gradation/week per type

5

Aggregates

- All personnel involved in aggregate sampling & testing need to be certified as aggregate technicians
- The QC inspector will monitor gradations by lot (1/week per type)
- QA will review fabricator (QC) gradation tests
- QA should run 1 or 2 tests a year to check QC

6

Sole Plates

- Approved Supplier – Maple – IM557
- Must have APPROVED Shop Drawings
- Must have a fabricator report indicating compliance with galvanizing coating thickness
  - The QA inspector can check the coating & make a report at the plant.

7

Coil Ties and Hold Downs

- Accepted per Manufacturer's certification, once per year per size

8

Black & Epoxy Coated Reinforcement

- Shall be from approved sources – MAPLE
- Certified Mill Test Reports from the supplier must accompany each shipment
  - A copy of the Mill Certs from each shipment goes to the QA Inspector
- All steel and iron products, and steel coatings, must satisfy the requirement of Materials IM 107 (Buy America)

9

Storing Reinforcement

- Minimize contamination and exposure to moisture
- Direct sunlight and weather exposure
- Shall remain bundled and tagged until all is used
- Long term storage should be avoided
- Do not place directly on the ground

10

7-Wire Prestressing Strands

- The Fabricator shall provide Certified Mill Tests Reports and Load Elongation Curve to the QA Monitor Every Load.
- Prestressed Strand may be accepted by Certification and Monitored by Sampling at a rate of 1-6' sample per heat #

11

7 Wire Prestressing Strand

All strands shall be free of contamination (dirt, mud, oil, paint, wax etc.) that prevents bonding between strands and concrete

- Strands shall be free from nicks, kinks, and excessive rust

(Rust is generally acceptable if the rust is light and is pitting is not evident)

12

Wire Failure

- During stressing of 7-Wire Strands, the number of wire failures shall not exceed 2% of the total number of wires
- NO INDIVIDUAL STRAND shall have more than 1 wire fail
- The permissible number of wire failure shall be rounded to the next lowest number

13

Wire Failure

- Example: BTD65
  - 2 deflected strands & 14 straight strands = 16 Strands
  - Each strand has 7 wires
  - 16 x 7 = 112 individual wires
  - Allowed 2% of the total numbers of wires
  - 112 x .02 = 2.24 (round to the next lowest number)

NO more than **2** wire failures

(can not round up to 3 because 2.24 is your max and 3 would be out so round down)

14

Class Example #2 Wire Failure

- BTE125
- Where do you find how many strands in Beam?
- Beam Standard Sheets or plans

15

BTE125

- 32 Straight Strand & 6 Deflected Strand
- Total of 38 Strand
- 38 x 7 = 266 total individual wires
- 266 x .02 = 5.32 SO = 5.0 total wires failures allowed

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ANY QUESTIONS ? ? ?

17

Shop Drawings

1

Shop Drawings
Introduction

- Purpose
- Process
- Approvals

2

Shop Drawings
Purpose

- Translates information
- Plan Details
- More usable form

3

Shop Drawings

- Separate a complex detail into smaller parts
- Add or enhance information that the fabricator may need

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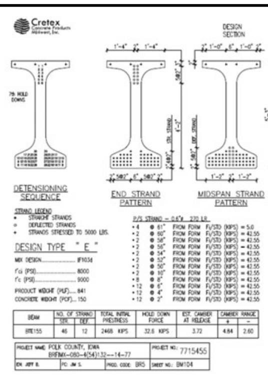

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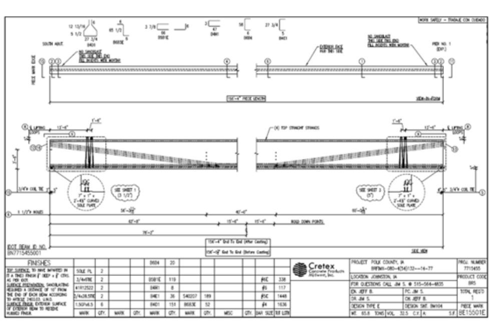

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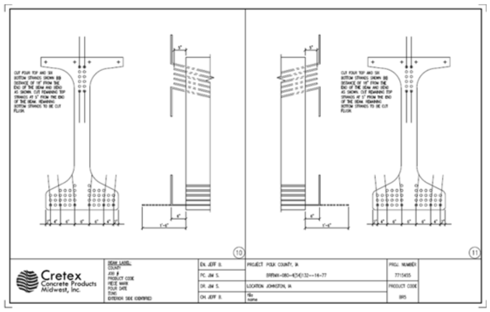

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Department Approval vs. no approval needed

8

No Department Approvals

- Routine production
- Line set ups
- Framing plans

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Department Approvals Required

- Fabricated Steel Components
- Steel Diaphrams
- Sole Plates
- Hangers
- Deck Panel Layout
- Alterations to Design

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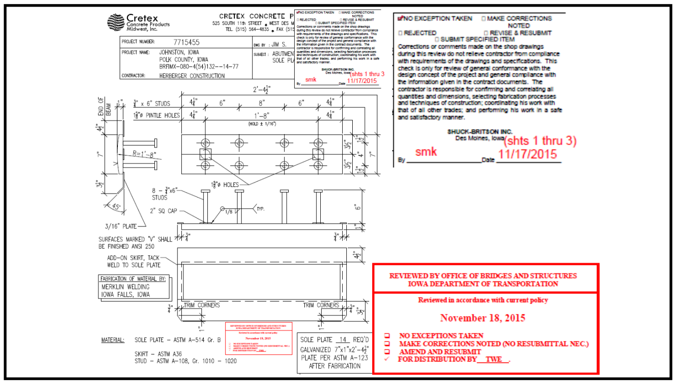

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Who Approves Shop Drawings??

- Approvals are made by the design engineer
- The Office of Bridges & Structures
- County or Consulting Engineer

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Approval Process

- Fabricator reviews plans/specifications
- Fabricator prepares the shop drawings
- Shop drawings are submitted to the design engineer
- Copies submitted to DME
- Before fabrication begins the fabricator must receive approval from the design engineer

13

Design Engineer Approval Disposition

- No exeptions noted
- Make corrections as noted (no resubmittal necessary)
- Amend and resubmit
- For distribution by___________________

14

Calibration of Tensioning System

1

Calibration of Tensioning System

- Calibration of the tensioning system gauges is required to assure that the correct prestressing force is applied to the strands.
- Iowa DOT Specifications have specific requirements to assure the applied force readings of the system are accurate.

2

Article 2407.03A.3 Stressing Equipment

"To tension tendons, use equipment of a type so the prestressing force may be accurately known."

3

Article 2407.03A.3
Stressing Equipment

"Use load cells, dynamometers, and hydraulic gages of hydraulic pump and jacking systems capable of measuring the force applied to the tendons within 2% of the actual force."

4

Calibration

"Determining the deviation from a standard so as to ascertain the proper correction factors."

Calibration should be both ACCURATE and PRECISE

5

Accurate vs. Precise
Webb's Definitions

- Accuracy refers to the closeness of the ***average measured value*** to the ***actual value***.
- Precision refers to the variability of the measured values from one another.

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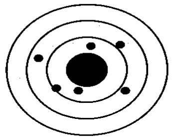
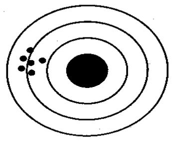
Accuracy - refers to the average of the performance with reference to the target.



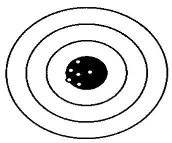
Not Good
Not Precise
Fairly Accurate

Precision - refers to the consistency of the performance itself.



Not Good
Precise
Not Accurate

Accurate and Precise: On target and closely grouped.



Good
Precise + Accurate

7

Calibration

- Compares the production device to a certified standard.
- Establishes a correction factor to production device readings to attain the actual required force.
- The Iowa DOT Specifications provide guidelines for these calibrations

8

Article 2407.03A.3

- Equipment at prestress plants must be calibrated at least every 12 months
- It must also be calibrated anytime the tensioning system indicates erratic results.

9

Article 2407.03.A3

- Hydraulic gauges, pumps, hoses and connections shall be calibrated as a system.
- If changes to system configuration occur, the equipment should be recalibrated.

10

Calibration Standards

- Standard Devices:
  - Load Cell
  - Pressure Gauge
  - Proving Ring
- Standard Devices shall have current calibration references linked to a National Standard.

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Calibration

- Calibrations shall be performed using load cells calibrated by a testing laboratory or calibration service.
- Engineer (DOT) shall be allowed to witness calibration during normal working hours or other mutually agreed time.

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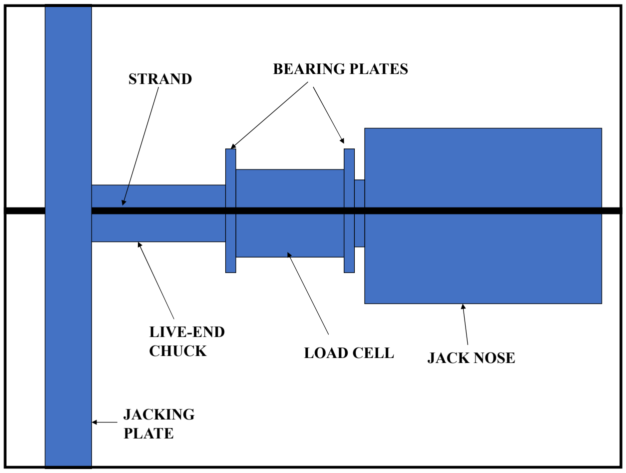

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Calibration Using Set-The-Force Method

- A pre-selected force is achieved by the tensioning system, indicated by calibration device; production device reading is immediately checked.
- System is consider acceptable if calibration device reading and production device reading are within 2% of one another.

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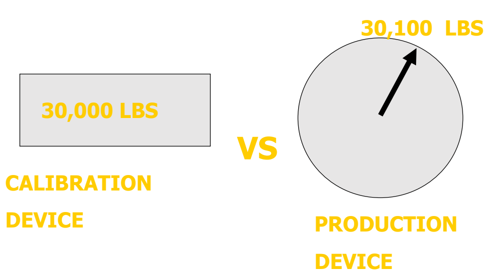
SET-THE-FORCE-METHOD



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Percent Accuracy

- Determination of Percent :Accuracy Error

$$\text{\% Accuracy error} = \frac{(\text{Average Reading} - \text{Target})}{\text{Target}} \times 100\%$$

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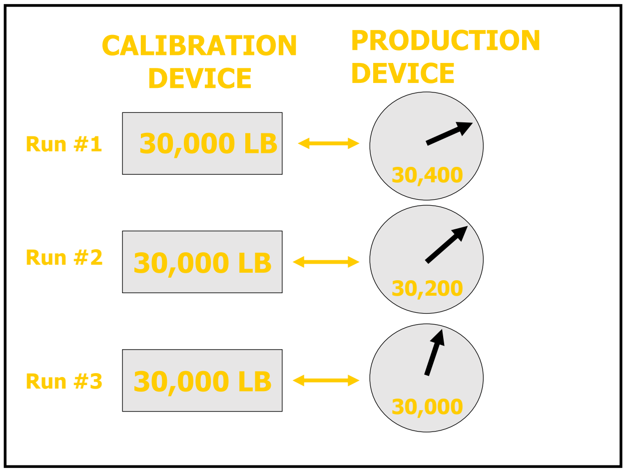

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Percent Accuracy Calculation

Determine Average Measure Force of Production Device

Run No.	Force Reading
1	30,400 lb
2	30,200 lb
3	30,000 lb
Average	30,200 lb

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Percent Accuracy Calculation

Determine Percent Accuracy:

$$\% \text{ Accuracy error} = \frac{(30{,}200 \text{ lb} - 30{,}000 \text{ lb})}{(30{,}000 \text{ lb})} \times 100\%$$

% Accuracy = 0.67%

Percent Accuracy is Within 2%

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Calibration Accuracy

- If percent calibration accuracy is more than 2%:
  - Recheck Calculations
  - Recalibrate
  - ~~Apply Correction Factor~~
  - Take out of Service and Repair

20

Calibration Precision Check

- Independent comparison between calibration device and production device.
- Based on single run loading – no averages.
- Percent Accuracy for all points should check within 2%.

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Calibration
Spot Check

- Independent comparison between calibration device and production device.
- Based on average of three load run measurements at same loading.
- Percent accuracy for average at each load point should check within 2%

22

Observation

- Producer QC inspector should witness calibration and spot check of system.
- Iowa DOT QA, when possible, should witness calibration and spot check of system.

23

Calibrations

- Initial Loading
- Single-Strand Loading
- Multi-Strand Loading
- Load Cell Systems

24

Calibration
Multi-Strand System

- Begin at lowest loading point, working up from there.
- Calibrate throughout the entire working range.
- Apply load, using Set-the-Force Method.
- Record the calibration device and production device readings.
- Release load and repeat process at least two more times.
- Determine Percent Accuracy at each load point.
- Graph or tabulate the results.

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Summary

- Calibrate system at least every 12 months or if erratic results are observed.
- Calibration performed by approved testing lab or certified calibration service.
- Use Set-the-Force Method.
- Calibration Percent Accuracy must be within ±2%.
- Precision is demonstrated.
- Spot checks done to verify accuracy.
- QC and QA should witness calibrations.

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Questions?

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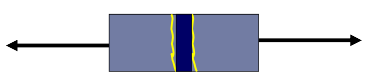
Prestressing Operations

1

Concrete Properties

- High Strength in Compression

- Low Strength in Tension



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Concrete Properties

- Compressive Strength = f'_c
- Tensile Strength = f'_t
- $f'_t = C * \sqrt{f'_c}$
- C = value usually from 6-9

3

Concrete Properties

What is the Tensile Strength, f'_t, when:

Compressive Strength = f'_c = 3500 psi, and

C = 7.5

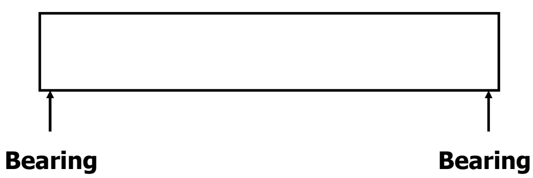
Tensile Strength= $f'_t = C * \sqrt{f'_c}$

$f'_t = 7.5 * \sqrt{3500}$

$f'_t = 443.7\ psi \approx 444\ psi$

4

Simple Beam



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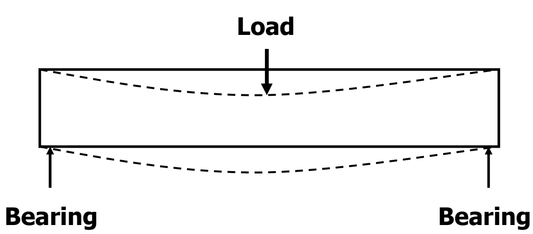
Simple Beam



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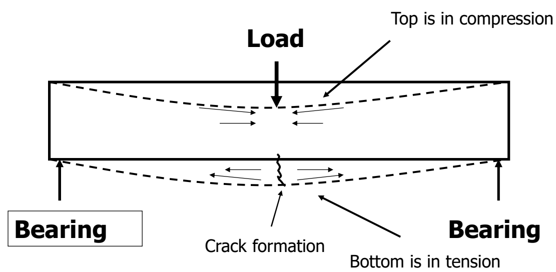
Internal Forces in the Beam



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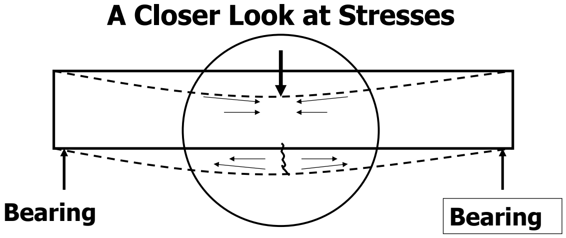
A Closer Look at Stresses



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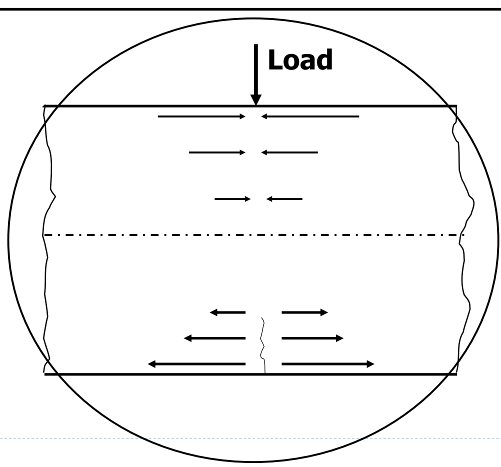

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Steel Reinforcement

- Reinforcing steel used to provide strength to concrete in tension
- Steel has high strength in tension: 60,000 psi
- Similar coefficient of thermal expansion to concrete

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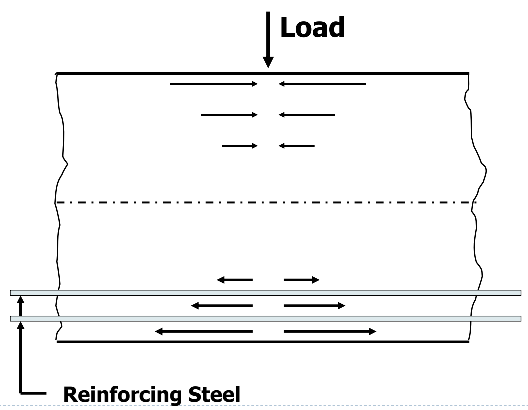

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Prestress Strand

- High strength steel (270,000 psi yield)
- Allows for application of prestress load into beam
  - Once tensile forces are transferred to the cured beam, compressive pre-load is introduced to offset design tensile stresses
- Prestress load improves concrete beam strength even more than reinforcing steel

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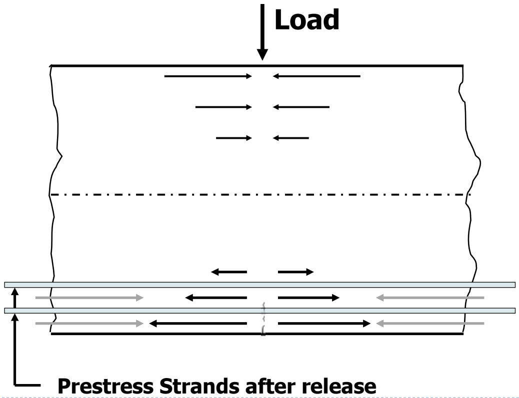

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Prestress Strand

- Strand consists of seven wires of high strength steel (270,000 psi yield)
- One wire in center with six helically winding around the center wire
- Very efficient load transfer

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Prestress Strand

- Sizes measured in overall diameter of 7-wire pack
- Each size has a different cross-sectional area (A)
- Larger A, larger prestress load that can be applied to strand

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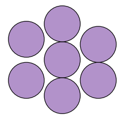
7-Wire Prestressing Strand



Standard Sizes	w/Approximate Areas
3/8″ strand	A = 0.085 in^2
½″ strand	A = 0.153 in^2
½″+ strand	A = 0.167 in^2
0.6″ (6/10ths) strand	A = 0.217 in^2

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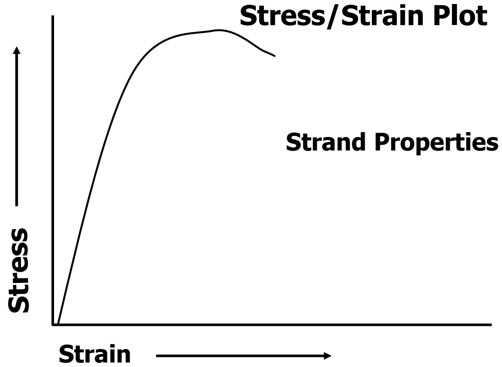
Stress/Strain Plot



Strand Properties

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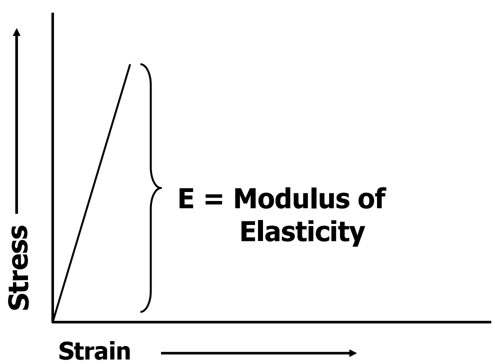
Stress/Strain Plot



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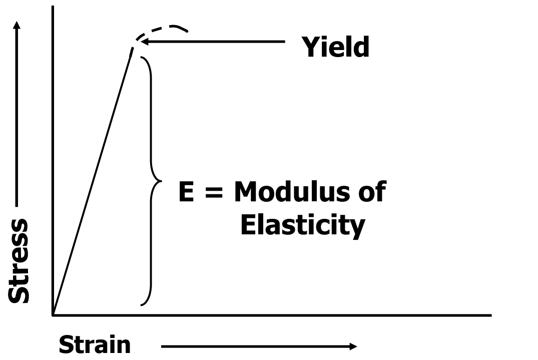
Stress/Strain Plot



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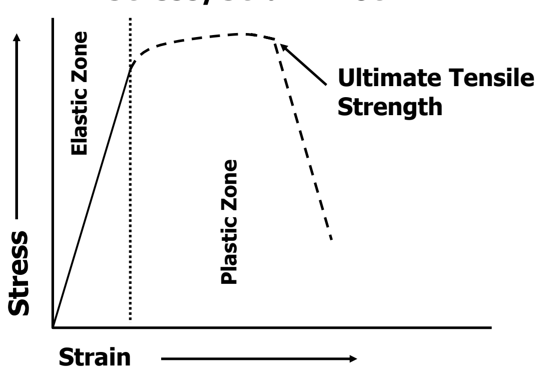
Stress/Strain Plot



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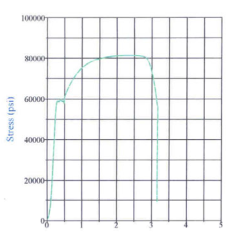

Test Results

Specimen Gage Length:	10.0000 in
Diameter:	0.7480 in
Area:	0.4394 in^2
Peak Load:	35749 lbf
Peak Stress:	81360 psi
Tangent Modulus:	3.2 Msi
Stress at Offset:	58690 psi
Load at Offset:	25790 lbf

Test Summary

Counter:	4218
Elapsed Time:	00:04:13
Lab:	? 23
Grade:	60 55
Procedure Name:	Rebar2
Start Date:	3/13/2007
Start Time:	10:16:52 AM
End Date:	3/13/2007
End Time:	10:21:05 AM
Workstation:	HWY06977
Tested By:	metals

21

Prestress Specifications

22

Standard Specification Article 2407

Precast and Prestressed Concrete Bridge Units

- Primary source in Specification Book for requirements regarding prestressed units:
  - Material requirements
  - Prestress fabrication requirements
  - Allowable tolerances
  - Handling and storage of units

23

Standard Specification Article 4151.05A

Uncoated Seven Wire Stress Relieved Strand

"Meet the requirements of AASHTO M 203, except furnish a load elongation curve for each heat number delivered. Low relaxation strand described in the AASHTO M 203 Supplement may be furnished at the Contractor's option."

AASHTO M 203 requires Grade 270 steel strand with ultimate strength of 270,000 psi (270 ksi)

24

Materials IM 570

- Materials Instructional Memorandum dedicated to fabrication of prestress units:
  - Approved producer requirements
  - Inspection requirements, QA and QC
  - Repair procedures
  - Glossary of terms
  - Other useful information

25

Standard Beam Details

- These provide the details for the standard beam fabrication:
  - Dimensions
  - Stressing requirements
    - Number of strands and type (straight, deflected)
    - Layout
  - Reinforcement
  - Other important details

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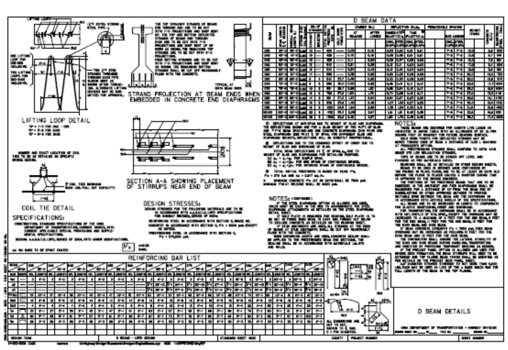
Standard Beam Details



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D BEAM DATA

BEAM	SPAN LENGTH ℄-℄ BEARING	OVERALL BEAM LENGTH (L)	STRAND SIZE DIA. (Inches)	NO. OF STRANDS STRAIGHT	NO. OF STRANDS DEFLECTED	TOTAL INITIAL PRESTRESS KIPS ③	HOLD DOWN FORCE-KIPS	CAMBER (In.) AT RELEASE	CAMBER (In.) AFTER LOSSES	DEFLECTION (In.) IMMEDIATE (ELASTIC) ① CONC. DIAPH.	DEFLECTION (In.) IMMEDIATE (ELASTIC) ① STEEL DIAPH.	DEFLECTION (In.) TIME (PLASTIC) ② CONC. DIAPH.	DEFLECTION (In.) TIME (PLASTIC) ② STEEL DIAPH.	PERMISSIBLE SPACING HL93 LOADING CONC. DIAPH.	PERMISSIBLE SPACING HL93 LOADING STEEL DIAPH.	WEIGHT (TONS)	CONCRETE (C.Y.)	REINFORCING STEEL - (lbs.)
D35	35'-0	36'-0	0.60	10	—	425	——	0.09	0.15	0.03	0.03	0.01	0.01	7'-6	7'-6	12.0	5.9	502
D40	40'-0	41'-0	0.60	10	—	425	——	0.10	0.18	0.05	0.05	0.01	0.01	7'-6	7'-6	13.6	6.7	541
D45	45'-0	46'-0	0.60	12	—	510	——	0.18	0.31	0.08	0.07	0.02	0.02	7'-6	7'-6	15.3	7.6	561
D50	50'-0	51'-0	0.60	12	—	510	——	0.21	0.36	0.12	0.11	0.03	0.03	7'-6	7'-6	17.0	8.4	624
D55	55'-0	56'-0	0.60	12	—	510	——	0.24	0.42	0.18	0.16	0.04	0.04	7'-6	7'-6	18.6	9.2	681
D60	60'-0	61'-0	0.60	14	—	596	——	0.35	0.62	0.25	0.22	0.06	0.06	7'-6	7'-6	20.3	10.0	720
D65	65'-0	66'-0	0.60	8	4	510	23.7	0.46	0.80	0.33	0.30	0.08	0.08	7'-6	7'-6	22.0	10.8	910
D70	70'-0	71'-0	0.60	8	6	596	30.0	0.52	0.92	0.45	0.41	0.11	0.10	7'-6	7'-6	23.6	11.7	1004
D75	75'-0	76'-0	0.60	10	6	681	26.7	0.69	1.22	0.58	0.54	0.15	0.13	7'-6	7'-6	25.3	12.5	1064
D80	80'-0	81'-0	0.60	12	6	766	27.2	1.00	1.76	0.74	0.69	0.19	0.17	7'-6	7'-6	27.0	13.3	1116
D85	85'-0	86'-0	0.60	14	6	851	27.3	1.27	2.24	0.94	0.87	0.23	0.22	7'-6	7'-6	28.6	14.1	1159
D90	90'-0	91'-0	0.60	16	6	936	25.8	1.40	2.46	1.07	1.00	0.27	0.25	7'-6	7'-6	30.4	15.0	1310
D95	95'-0	96'-0	0.60	18	6	1021	24.5	1.64	2.89	1.32	1.24	0.33	0.31	7'-6	7'-6	31.9	15.8	1493
*D100	100'-0	101'-0	0.60	22	6	1192	22.3	2.08	3.67	1.61	1.51	0.40	0.38	7'-6	7'-6	33.6	16.6	1521
*D105	105'-0	106'-0	0.60	26	6	1362	22.2	2.42	4.27	1.80	1.70	0.45	0.42	7'-6	7'-6	35.3	17.4	1602

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BEAM NOTES:

THESE BEAMS ARE DESIGNED FOR AASHTO LIVE LOADS AS INDICATED IN ABOVE TABLE WITH AN ALLOWANCE OF 20 lb. PER SQUARE FOOT OF ROADWAY FOR FUTURE WEARING SURFACE.

ALL PPC BEAMS SHALL USE HIGH PERFORMANCE CONCRETE (HPC) IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS.

HOLD DOWN POINTS FOR DEFLECTED STRANDS MAY BE MOVED TOWARD ENDS OF BEAM A DISTANCE OF 0.05 L MAXIMUM AT PRODUCER'S OPTION.

ALL PRESTRESSING STRANDS SHALL CONFORM TO ASTM A416 GRADE 270 LOW RELAXATION STRANDS.

TOPS OF BEAMS ARE TO BE STRUCK OFF LEVEL AND FINISHED AS PER MATERIALS IM570.

BEARINGS SHALL BE AS DETAILED ON OTHER DESIGN SHEETS.

BEAMS TO BE USED IN BRIDGES MADE CONTINUOUS BY THE POURED IN PLACE FLOOR, ARE TO BE AT LEAST 28 DAYS OLD BEFORE THE FLOOR IS PLACED UNLESS A SHORTER CURING TIME IS APPROVED BY THE BRIDGE ENGINEER.

THE PORTIONS OF THE PRESTRESS BEAMS THAT ARE TO BE EMBEDDED IN THE ABUTMENT AND PIER DIAPHRAGMS SHALL BE ROUGHENED FOR A DISTANCE OF 10" FROM THE BEAM END BY SANDBLASTING OR OTHER APPROVED METHODS TO PROVIDE SUITABLE BOND BETWEEN THE BEAM AND THE DIAPHRAGM IN IN ACCORDANCE WITH ARTICLE 2403.03, I, OF THE STANDARD SPECIFICATIONS.

ALL BEAMS ARE TO BE INCREASED IN LENGTH TO COMPENSATE FOR ELASTIC SHORTENING, CREEP AND SHRINKAGE.

FOR TRANSPORTING, THE OVERHANG SHALL BE IN ACCORDANCE WITH ARTICLE 2407.03, K, OF THE STANDARD SPECIFICATIONS, EXCEPT EXCEPT THE OVERHANG MAY BE INCREASED TO A MAXIMUM OF 8 FEET FOR THE D85 BEAM, 9 FEET FOR THE D90 BEAM, 11 FEET FOR THE D95 BEAM, 12 FEET FOR THE D100 BEAM, AND D105 BEAM.

THE CONTRACTOR SHALL ASSURE THE LATERAL STABILITY OF THE D100 AND D105 BEAMS DURING HANDLING, TRANSPORTING AND ERECTION BY PROVIDING TEMPORARY BRACING AS NEEDED.

IF THE PRECAST PANEL OPTION IS ALLOWED AND USED FOR BRIDGE DECK FORMATION, THE BEAM STIRRUPS WILL NEED TO BE EXTENDED AND TOP FLANGE BEAM FINISH SHALL BE MODIFIED AS PER DETAILS ON THE PRECAST DECK PANEL SHEET.

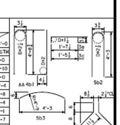
0.6" DIAMETER STRANDS STRESSED TO NOT MORE THAN 5,000 LBS. EACH MAY BE USED IN LIEU OF THE a BARS WHICH RUN THE FULL LENGTH OF THE BEAM IN THE TOP FLANGE.

29

REINFORCING BAR LIST

BAR	SHAPE	D35 35'-0 NO.	D35 LENGTH	D40 40'-0 NO.	D40 LENGTH	D45 45'-0 NO.	D45 LENGTH	D50 50'-0 NO.	D50 LENGTH	D55 55'-0 NO.	D55 LENGTH	D60 60'-0 NO.	D60 LENGTH
4a1	—	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0
a2	—	—	—	—	—	—	—	—	—	—	—	—	—
a3	—	—	—	—	—	—	—	—	—	—	—	—	—
ΔΔ4b1		33	10'-4	37	10'-4	39	10'-4	43	10'-4	47	10'-4	51	10'-4
5b2		12	8'-8	12	8'-8	12	8'-8	14	8'-8	14	8'-8	14	8'-8
5b3		4	4'-4	4	4'-4	4	4'-4	4	4'-4	8	4'-4	8	4'-4
3c		33	2'-1	37	2'-1	39	2'-1	43	2'-1	47	2'-1	51	2'-1
3d		45	5'-7	49	5'-7	51	5'-7	57	5'-7	61	5'-7	65	5'-7
3e		26	2'-3	26	2'-3	26	2'-3	28	2'-3	28	2'-3	28	2'-3

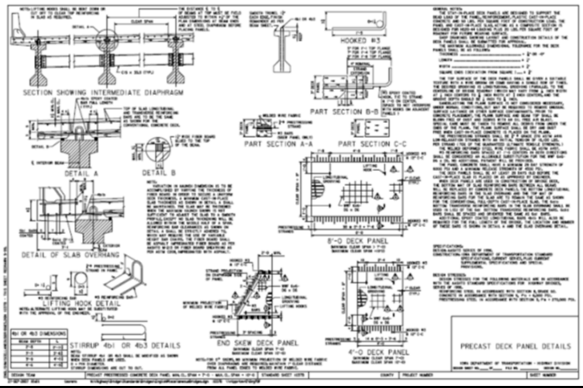
BAR	D65 65'-0 NO.	D65 LENGTH	D70 70'-0 NO.	D70 LENGTH	D75 75'-0 NO.	D75 LENGTH	D80 80'-0 NO.	D80 LENGTH	D85 85'-0 NO.	D85 LENGTH	D90 90'-0 NO.	D90 LENGTH	D95 95'-0 NO.	D95 LENGTH	D100 100'-0 NO.	D100 LENGTH	D105 105'-0 NO.	D105 LENGTH
4a1	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	16'-0	2	18'-0	2	20'-0	2	22'-0	2	24'-0
a2	5/4	22'-10	5/4	24'-4	5/4	25'-10	5/4	27'-4	5/4	29'-4	5/4	30'-10	6/4	32'-10	6/4	35'-4	6/4	36'-10
a3	6/2	25'-0	6/2	27'-0	6/2	29'-0	6/2	31'-0	6/2	32'-0	7/2	34'-0	8/2	36'-0	8/2	36'-0	8/2	38'-0
ΔΔ4b1	53	10'-4	57	10'-4	62	10'-4	66	10'-4	68	10'-4	74	10'-4	80	10'-4	81	10'-4	87	10'-4
5b2	14	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8
5b3	8	4'-4	12	4'-4	12	4'-4	12	4'-4	12	4'-4	20	4'-4	20	4'-4	20	4'-4	20	4'-4
3c	53	2'-1	57	2'-1	62	2'-1	66	2'-1	68	2'-1	74	2'-1	80	2'-1	81	2'-1	87	2'-1
3d	67	5'-7	73	5'-7	78	5'-7	82	5'-7	84	5'-7	90	5'-7	96	5'-7	97	5'-7	103	5'-7
3e	28	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3



ALL DIMENSIONS ARE OUT TO OUT.
RADIUS TO ℄ BAR.
D = PIN DIAMETER.

30

Precast Deck Panels Details



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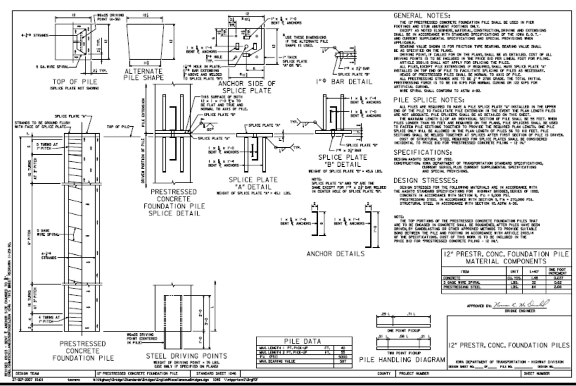
Prestress Concrete Pile Details



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Article 2407.03G7

"Temporary overstressing of the tendons is allowed; however at no time exceed 80% of the specified tensile strength of the tendons. Do not seat tendons in this overstress condition."

How do we determine what this maximum prestress load is for a given strand?

33

Maximum Prestress Load

Maximum Prestress Load =
80% x Cross Sectional Area x Ultimate Strength
or-
(0.80) x (A in^2) x (270,000 psi)

34

Maximum Prestress Load

For ½" strand find the maximum prestress load.

Given: Area= A=0.153 in^2
Ultimate Strength=270,000psi

Max Load = (0.80)(0.153 in^2)(270,000 psi)
= 33,048 lb

35

Maximum Prestress Load

For 0.6" strand, find the maximum prestress load.

Given: Area=0.217 in^2
Ultimate Strength=270,900psi

36

Maximum Prestress Load

For 0.6" strand, find the maximum prestress load.

Given: Area=0.217 in^2
Ultimate Strength=270,900psi

Max Load = $(0.80)(0.217\ in^2)(270{,}900\ psi)$
= 47028 lb

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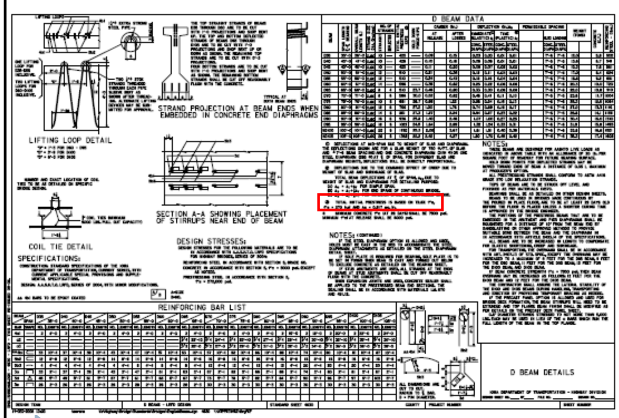

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③ TOTAL INITIAL PRESTRESS IS BASED ON 72.6% f's,
f's = 270 ksi AND As = 0.217 sq. in.

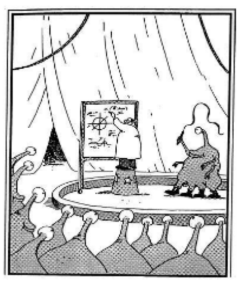
- Beam designs on current Standard Bridge Plans based on 72.6% of ultimate strength for A-D and BTB-BTE beams.
- Older LX and BT series beams were based on 75%.
- Precast Deck Panels are based on 70%.
- Concrete Pile initial prestress is not defined as a percent of ultimate strength, but is set at about 45% for 270 grade strand.
- Box beams are based on 72.6% of ultimate strength.

39

Any Questions?

40

Higher Math

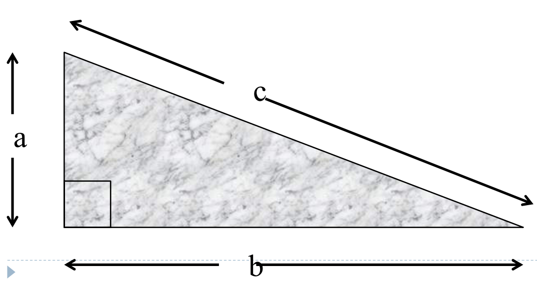


Abducted by an alien circus company, Professor Doyle is forced to write calculus equations in center ring.

41

$$c^2 = a^2 + b^2$$

$$c = \sqrt{a^2 + b^2}$$



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$$P_i \text{ (lb)} = \frac{\textit{Total Initial Prestress for Beam (lb)}}{\textit{Total Number of Strands in Beam}}$$

43

$$\Delta = \frac{P * L}{A * E}$$

Δ= change in length (elongation)
P = load in pounds
L = length in inches
A = area in square inches
E = modulus of elasticity in lbs./in^2

44

OR

$$P = \frac{\Delta * A * E}{L}$$

Δ = change (we will use elongation)
P = load in lbs.
L = length in inches
A = area in in^2
E = modulus of elasticity in lbs./in^2

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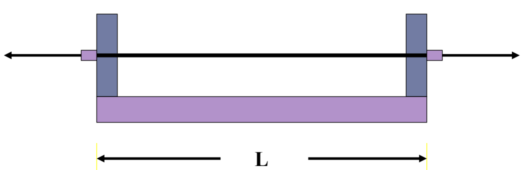
Prestressing Basics

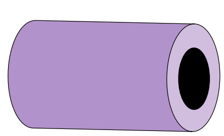
1

Basic Prestressing Layout



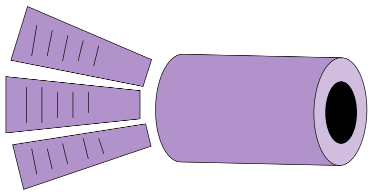
2

Strand Chuck



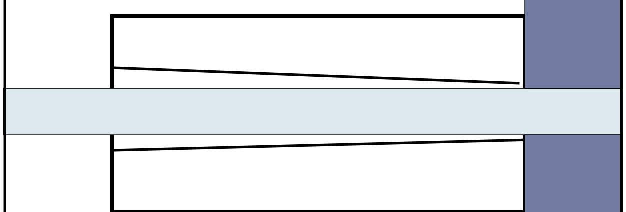
3

Strand Chuck



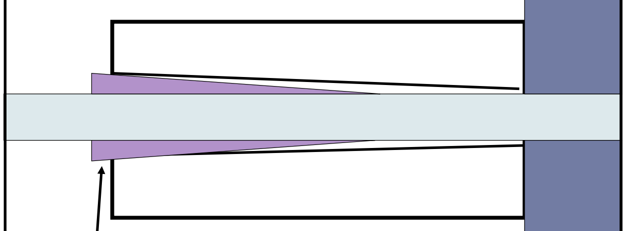
4

Strand Chuck



5

Strand Chuck



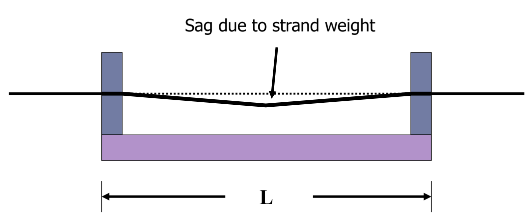
6

Seating Losses

- Live End (Jacking End)
  - Slippage of strand when engaging in chuck
  - Loss of elongation and tension
- Dead End
  - Slippage of strand when engaging in chuck
  - Loss of Elongation
- Splice Chuck
  - Slippage of strand within swedge/chuck
  - Loss of elongation

7

Prior to Stressing



8

Article 2407.03G3

- Allows for preloading of strands to take sag out of the strands:

"After tendons have been positioned, apply an initial force between 1,000 and 4,500 pounds (4.5 kN and 20 kN) to each tendon."

9

Article 2407.03G3

- "Measure the initial force within a tolerance of:
  - ± 100 pounds (0.5 kN) for initial forces under 3000 pounds (13 kN)
  - ± 200 pounds (1 kN) for initial forces of 3000 pounds (13 kN) or more."

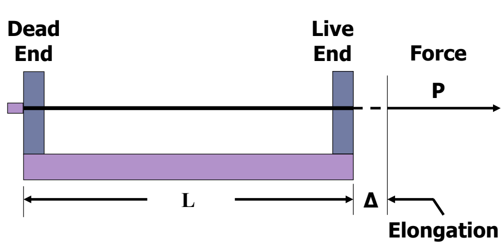
10

Tensioning Methods

- Single-strand tensioning
  - Each individual strand is pulled separately
- Multi-strand tensioning
  - A group of strands or all strands are pulled together in one operation

11

Basic Prestressing



Steel Strand Characteristics:
Cross Sectional Area A
Modulus of Elasticity E

12

Basic Strand Calculations

Calculations will use some or all of these components:

Δ = Strand elongation (in)

P = Applied prestress force (lb)

L = Chuck-to-chuck strand length (in)

A = Cross-sectional strand area (in^2)

E = Strand modulus of elasticity (psi)

13

Elongation Calculation

- Elongation calculation for a given force:

$$\Delta = \frac{P*L}{A*E}$$

14

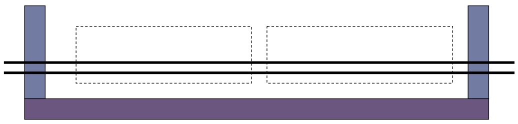
Force Calculation

- Force calculation for a given elongation:

$$P = \frac{\Delta*A*E}{L}$$

15

Bed Set Up with Straight Strand



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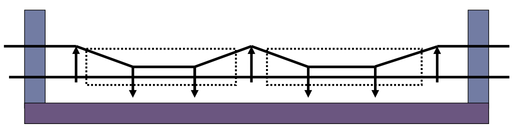
Bed Set Up with Deflected Strand



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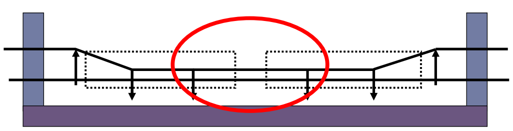
Bed Set Up for Harped Strand



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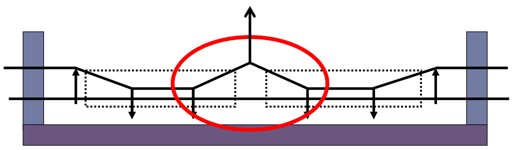
Bed Set Up for Harped Strand



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Self-Stressing Beds

Plan View

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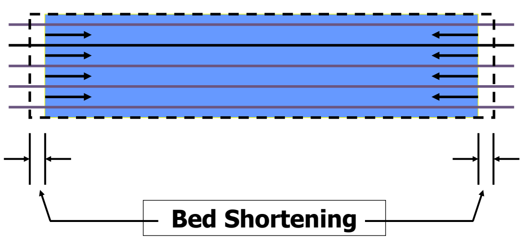
Self-Stressing Beds



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Tensioning Calculations Corrections

- Live End Seating
- Dead End Seating
- Splice Chucks
- *Temperature Correction*
- *Abutment Rotation*

22

Temperature Correction

- Due to thermal expansion or contraction from a baseline 70°F setup
- Corrections may be + or – (unlike seating/splice losses which are always added)
- Adjustment is 1% per 10°F temperature change

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TEMPERATURE CORRECTIONS

Table 2407.03-2: Initial Prestressing Force	
Temperature of Strands	Initial Prestressing Force
70 degrees F	As shown in the contract documents
Below 70 degrees F	Increase 1.0% per 10 degrees F
Above 70 degrees F	Decrease 1.0% per 10 degrees F

Article 2407 of Standard Specifications

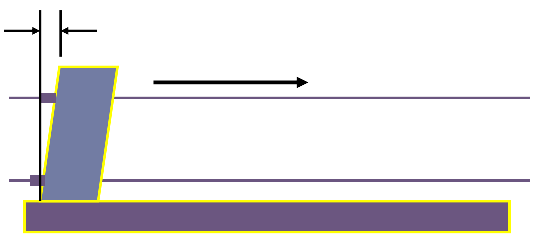
Temperature Range (degrees F)	Percent Adjustment
100 to 109 degrees	-3% (x -0.03)
90 to 99 degrees	-2% (x -0.02)
80 to 89 degrees	-1% (x -0.01)
71 to 79 degrees	0% (x 0.00)
70 degrees	0% (x 0.00)
61 to 69 degrees	0% (x 0.00)
51 to 60 degrees	+1% (x 0.01)
41 to 50 degrees	+2% (x 0.02)
31 to 40 degrees	+3% (x 0.03)
21 to 30 degrees	+4% (x 0.04)
11 to 20 degrees	+5% (x 0.05)
1 to 10 degrees	+6% (x 0.06)

24

Abutment Rotation

25

Abutment Rotation



Increases Elongation

No Increase in Tension

26

Any Questions?

27

Basic Strand Tension Calculations

1

Basic Strand Calculations

Method of elongation calculation for prestress strands based on the following relationship:

$$\Delta = \frac{P*L}{A*E}$$

2

Basic Strand Calculations

$$\Delta = \frac{P*L}{A*E}$$

Δ = Strand elongation (in)
P = Applied prestress force (lb)
L = Chuck-to-chuck strand length (in)
A = Cross-sectional strand area (in^2)
E = Strand modulus of elasticity

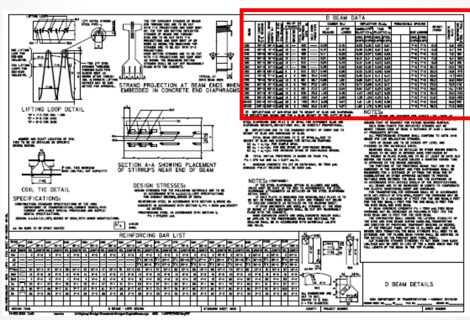
3

Prestress Force Determination

- Overall initial prestress force per strand (P_i) must be determined
- Prestress Beam Standard Plan
  - Overall prestress force in beam given
  - Need to determine total force per single strand
- Correction for initial preload force must be applied

4

Standard Plan Sheets



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D BEAM DATA

BEAM	SPAN LENGTH ℄-℄ BEARING	OVERALL BEAM LENGTH (L)	STRAND SIZE DIA. (inches)	NO. OF STRANDS STRAIGHT	NO. OF STRANDS DEFLECTED	TOTAL INITIAL PRESTRESS KIPS	HOLD DOWN FORCE-KIPS	CAMBER (in.) AT RELEASE	CAMBER (in.) AFTER LOSSES	DEFLE[CTION] IMMEDIAT[E] (ELASTIC) CONC. DIAPH.	STE[EL] DIA[PH.]
D35	35'-0	36'-0	0.6	10	—	425	—	0.09	0.15	0.03	0.0
D40	40'-0	41'-0	0.6	10	—	425	—	0.10	0.18	0.05	0.0
D45	45'-0	46'-0	0.6	10	—	425	—	0.11	0.20	0.08	0.0
D50	50'-0	51'-0	0.6	12	—	510	—	0.21	0.36	0.12	0.1
D55	55'-0	56'-0	0.6	12	—	510	—	0.24	0.42	0.18	0.1
D60	60'-0	61'-0	0.6	14	—	596	—	0.35	0.62	0.25	0.2
D65	65'-0	66'-0	0.6	8	4	510	23.7	0.46	0.80	0.33	0.3
D70	70'-0	71'-0	0.6	8	6	596	30.0	0.52	0.92	0.45	0.4
D75	75'-0	76'-0	0.6	10	6	681	26.7	0.69	1.22	0.58	0.5
D80	80'-0	81'-0	0.6	12	6	766	[illegible]	1.00	1.76	0.74	0.6
D85	85'-0	86'-0	0.6	14	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.8
D90	90'-0	91'-0	0.6	16	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0
D95	95'-0	96'-0	0.6	18	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2
*D100	100'-0	101'-0	0.6	22	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5
*D105	105'-0	106'-0	0.6	26	6	1362	22.2	2.42	4.27	1.80	1.7

Total Strands = 14

Total Prestress = 596 kips

6

Prestress Force Determination

Initial Prestress Force, P_i

$$P_i \text{ (lb)} = \frac{\text{Total Initial Prestress for Beam (lb)}}{\text{Total Number of Strands in Beam}}$$

$$P_i \text{ (lb)} = \frac{(596 \text{ kips})(1000 \text{ lb/kip})}{14 \text{ strands}}$$

$$P_i \text{ (lb)} = 42{,}571 \text{ lb/strand}$$

7

Overall Length of Strands (L)

- The overall chuck-to-chuck length of the prestress strands in the setup (L) must be determined
  - For parallel strands this would be the length of the setup
  - For deflected strands the length needs to be adjusted for additional length due to diagonal strand positions

8

Cross-sectional Area (A) and Modulus of Elasticity (E)

- These values are strand properties that will vary by strand size and by variable material characteristics in each lot of material
- Values for these properties are found in the mill certifications that accompany the strand packs

9

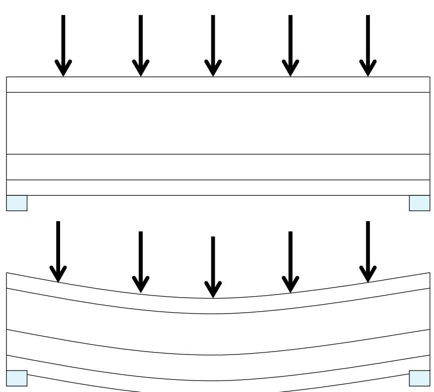
Deflected Strand Tension Calculations

1

Deflected Strands

- In some instances, deflected strands are required for some beam setups.
- Usually in the longer beam sizes.
- The deflection into the bottom flange of the beam at the midpoint provides upward force to resist the downward vertical force when the beam is loaded.

2



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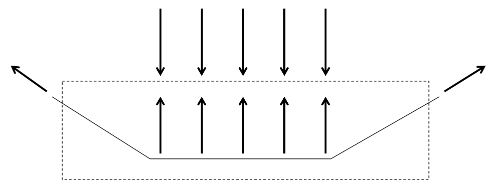


Upward force generated by draped strands resists some of the downward force applied by loading.

4

Deflected Strands

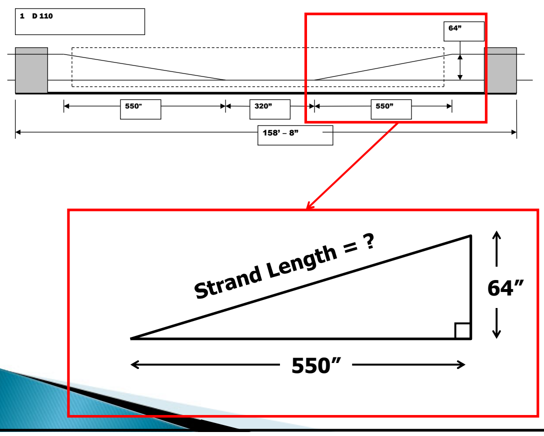
- Tensioning calculations for deflected strands are similar to parallel strands.
- Parallel strand length is the same as the bed setup length abutment-to-abutment.
- Deflected strand length (L) is longer than the abutment-to-abutment length due to the diagonal sections of the setup.

5

Deflected Strands

- Total additional setup length caused by diagonals must be determined to find "L".
- Once "L" is determined, the calculation procedure is the same as before: determine Δ , calculate adjustments for seating, temperature, etc.

6



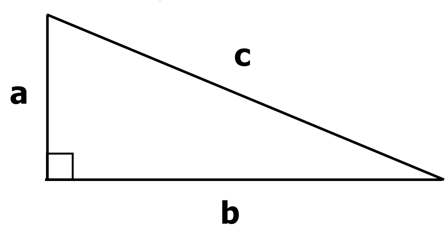
7

Deflected Strands

- How do we determine the diagonal strand length so we can determine the additional length to add to the setup length?
- Use the Pythagorean Theorem.
  - Equation developed by mathematician Pythagoras in Ancient Greece (6th century B.C.)
  - Relationship between side lengths of right triangles

8

Pythagorean Theorem



$$(a*a) + (b*b) = (c*c)$$

or

$$a^2 + b^2 = c^2$$

9

Pythagorean Theorem

$$a^2 + b^2 = c^2$$

$$c^2 = a^2 + b^2$$

$$\sqrt{c^2} = \sqrt{a^2 + b^2}$$

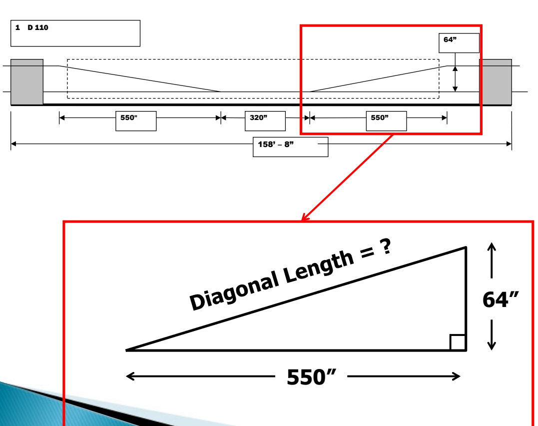
$$\mathbf{c = \sqrt{a^2 + b^2}}$$

10

Deflected Strands

- Determining the “L” length:
  - Use Pythagorean Theorem to determine the length of the diagonal.
  - Determine additional length per diagonal by subtracting horizontal length from diagonal length (c – b).
  - Determine number of diagonals and multiply the additional length by that number.
  - Add this adjustment to the total horizontal bed setup length.

11



12

Deflected Strand Length

- Use Pythagorean Theorem to determine diagonal length, c:

$$a^2 + b^2 = c^2$$

$$c = \sqrt{a^2 + b^2}$$

a = 64 in b = 550 in

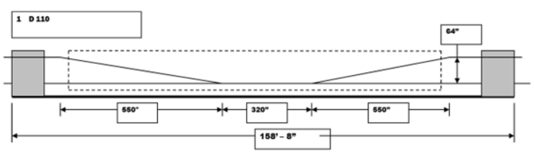
$$c = \sqrt{(64in)^2+(550in)^2} = \sqrt{4096in^2 + 302{,}500in^2}$$

$$= \sqrt{306{,}596in^2}$$

553.711 in

13

Horizontal Length of Bed Setup



From Layout,
Length Chuck to Chuck = 158' – 8"

Convert to inches
(158 ft x 12 in/ft) + 8 in = 1896 + 8
= 1904 in

14

Deflected Strand Length

- Additional length per diagonal
  = c – b = 553.711 in – 550 in = 3.711 in
- Number of diagonals = 2
- Deflected Strand Length, L:

L = 1904 in + (2 diagonals x 3.711 in/diagonal)

L = 1904 in + 7.422 in

L = 1911.422 in

15

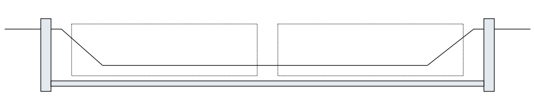
Harped Strand Tension Calculations

1

Harped Strands

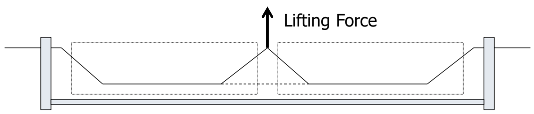
- In some cases, deflected strands are harped to achieve proper stressing.
- In this case the strands are tensioned to a calculated amount with the strands in a horizontal position within the setup.
- At the proper location to achieve the correct deflection, the strands are vertically lifted to get the remain tension and to get the strands in the proper deflected alignment.

2



Prior to Harping: Initial portion of elongation and stressing completed

3



After Harping: Remaining portion of elongation and stressing completed

4

Video of Harping

5

Harped Strands

- Tensioning calculations for harped strands require some additional steps compared to the calculations for deflected strands.
- The equations required for these additional calculations are the same as for deflected strands:

$$\Delta = (PL) / (AE)$$

$$a^2 + b^2 = c^2$$

6

Harped Strands

- Force determination for the harping process is calculated by determining the elongation of the deflected strands due to harping.
- This harping force is deducted from the total prestress required.
- The remaining prestress force is then used to determine elongation.

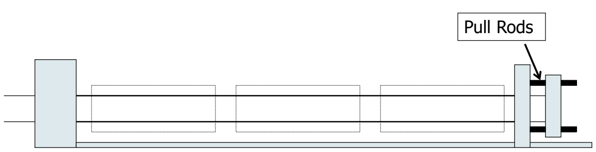
7

Multi-Strand Tension Calculations

1

Multi-Strand Stressing

- In some instances, all of the strands are pulled simultaneously to the required tension.



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Multi-Strand Stressing

- Tensioning calculations for multi-strand tensioning is similar to parallel strand tensioning.
- The calculations in multi-strand stressing consider all the strands in the configuration when determining the required forces and elongations.

3

Self-Stressing Bed Tension Calculations

1

Self-Stressing Beds

- Sometimes utilized in deck panel and concrete piling fabrication.
- Stressing calculations are a little different in the adjustments required:
  - No temperature correction needed since the casting bed is fully self-contained.
  - Self stressing adjustment needed in lieu of temperature correction.

2

Self-Stressing Beds

- Self stressing adjustment (SSA) is comprised of two factors:
- Overall bed shortening.
- Shortening per strand.

- SSA = ½ Measured Total Bed Shortening + Shortening per Strand

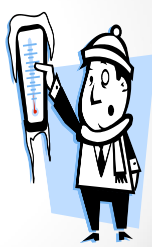
3

Cold Weather Tensioning Options

1

Cold-Weather Tensioning

- Tensioning in cold weather conditions can present some challenges.
- To better understand this, a review of temperature correction and its affects is needed.



2

Cold-Weather Tensioning

- Maximum tension permissible for prestressing strand is 80% of minimum ultimate tensioning strength, f's (Article 2407.03G7).

For ½" strand and the minimum f's:

80% f's = (0.80)(270,000 psi)(0.153 in^2)
= 33,048 lb

3

Cold-Weather Tensioning

- Let's assume that for a given 12 Inch Concrete Pile bed setup, gross prestress force required (P) is calculated to be 30,500 lb at 70°F.
- If we need to adjust for temperature, use the temperature correction factors in the table – assume that initial prestress for this setup is 31,500 lb.

4

Cold-Weather Tensioning

12 Inch Concrete Pile using ½" strand
Calculated Gross Prestress Force = 30,500 lb
For Initial (Net) Prestress = 31,700 lb
Maximum Prestress Force Allowed = 80% f's = 33,048 lb

Temperature (°F)	Correction Factor (%)	Correction Factor (lb)	Adjusted Gross Prestress (lb)
70°	-	-	31,700 lb
60°	+1%	305 lb	32,005 lb
40°	+3%	915 lb	32,615 lb
20°	+5%	1,525 lb	33,225 lb
0°	+7%	2,135 lb	33,835 lb

Gross Prestress > 80% f's

5

Cold-Weather Tensioning

- What are our options if the prestress force necessary exceeds 80% f's in cold weather?
- Materials IM 570, Appendix D:
  - Substitute ½"+ for ½" diameter strand.
  - Preheat strand.
  - Add strands of the plan-specified size

6

Strand Substitution

- An increase in the strand size (diameter) permits larger prestress force (80% f's) in the strand:

80% f's for ½" strand: 33,048 lb
½"+ strand: 36,072 lb

(assuming f's = 270,000 psi)

7

Preheat Strand

- Preheating strand reduces the additional temperature induced force in the strand.

For the example we have:
Increase strand temperature from 0° F to 40°,

Reduces temperature-related tension from 2,135 lb to 915 lb,

A total reduction of 1,220 lb – back under 80% f's.

8

Addition of Strand

- The use of additional strands lowers the required prestressing force per strand in the beam
- The basic force is lowered by distributing the total initial prestress force from the Beam Data table among more strands
- The table in IM 570 Appendix D lists "pre-approved" standard beams that require 75% of f's for the initial prestress and preapproved added strand counts and locations.
- Adding strands to beams that are not in the table and/or have 72.62% of f's for the initial prestress must be approved by the District Materials Engineer.

9

Addition of Strand

- IM 570 Appendix D Requirements
  - All added strands shall be straight strands of the same size as those specified for the member.
  - Strand pattern shall be the same as the standard plan except for the added strands.
  - Added strands shall be placed symmetrically about the member's centerline and spaced 2 inches, CL to CL, from existing strands.
  - Total initial prestress shall be the same as specified on the standard plan.
  - Adding costs for materials and labor shall be incidental to the cost of the fabrication of the prestressed unit.

10

Any Questions?

11

ACCEPTANCE OF TENSIONING

1

- All plants employ a jacking system to elongate the strand to a predetermined length that coincides with a required tensile force within the strand.
- Both the actual strand elongation and the force used to produce it are measured and compared to the theoretical elongation and calculated force needed.
- Other checks, most of which are performed prior to tensioning, are also used to assist in producing prestress units with the required characteristics (proper camber, minimal sweep, etc.)

2

3

Elongation Check

- Theoretical net elongation is considered the TARGET.
- The acceptable tolerance is + ½" from the theoretical net elongation.
- For example:
  - Net elongation is calculated to be 12 1/8 inches.
  - Measured elongation may be 11 5/8 to 12 5/8 inches

4

Force Check

- The calculated force required to produce the theoretical net elongation is considered the TARGET.
- The acceptable tolerance is + 5% of the calculated gross force.
- For example:
  - Calculated force needed to obtain elongation is 30,000 lbs.
- 30,000 x 0.95 = 28,500 lbs minimum
- 30,000 x 1.05 = 31,500 lbs maximum

5

Maximum Force Check

- At no time shall the strand experience a force greater than 80% of the specified tensile strength of the strand, including all allowable losses such as:
  - seating losses
  - bed shortening
  - abutment rotation
  - temperature adjustments
- For example, with a 0.6" strand with the specified minimum ultimate tensile strength:
  - 270,000 psi x 0.217 in2 = 58,590 lbs yield force
  - 58,590 lbs x 0.80 = 46,872 lbs gross force allowed

6

Maximum Force Check

- If 80% of the ultimate strength is less than the upper tolerance (105% of gauge pressure), the 80% of ultimate strength shall be the upper limit.
- For example, for ½" strand with a 32,000 lb. target force:
  - 80% of minimum ultimate strength is about 33,000 lb.
  - Range with + 5% of 32,000 lb would be 30,400 to 33,600 lb.
  - Range used during tensioning must be 30,400 to 33,000 lb. or -5% to approx. +3%.

7

Tensioning Procedure Check

- Normally stressing proceeds from the top to the bottom.
- If draped strands are used and they will be harped, the draped strand are first pulled to an intermediate predetermined value.
- The draped strands are then lifted into their final position, beginning as close to the center of the layout as possible and then proceeding alternately to either side of the center so that the final lift is made closest to the live end.

8

Wire Failure in Tendons

- Number of individual wire failures shall not exceed 2% of the total number of wires within unit
- Permissible number of wire failures shall be rounded to the next lower whole number.
- No more than 1 individual wire per tendon may fail
- For example:
  - BTD125 has 48-seven wire strands
  - Total number of wires is 48 x 7 = 336
  - 336 x 0.02 (2%) = 6.72; so 6 total allowed wire failures

9

Multiple Strand Tensioning

- After the tendons have been positioned, an initial force between 1000 and 4500 lbs is applied to the group. The group is then elongated to a predetermined length (theoretical net elongation).
- Actual elongation and the force applied by the jacking system are measured.
- Elongation check is performed for an individual strand.
- Force check is performed for the total group.

10

Strand Placement

- Strands are placed in same pattern and spacing as shown on beam standards or approved shop drawings
- Placed within tolerances:
  - Center of gravity of straight strand group + ¼”
  - Center of gravity draped strand group +1” at beam end
- Position of deflection points (hold downs) for deflected strands 5% of beam span towards beam end

11

Table 2407.03-3: Tolerances

Length	±1/4" per 25' and ±1" max. for beams 100' or longer
Width (flanges and fillets)	+3/8" or -1/4"
Depth (overall)	+1/2" or -1/4"
Width (web)	+3/8" or -1/4"
Depth (flanges and fillets)	±1/4"
Bearing plates (ctr. to ctr.)	1/8" per 10' of beam length, max. ±3/4"
Sweep (deviations from straight line parallel to center line of member)	L/80 (L in feet, sweep is in inches)
Camber deviation from design camber	±30% of plan camber
Stirrup bars (project above top of beam)	+1/4" or -3/4"
Individual tendon position	
Straight strands	±1/4"
Draped strands at end of beam	±1/2"
Tendon position	
Center of gravity of strand group	±1/4"
Center of gravity of depressed strand group at end of beam	±1"
Deviation from net theoretical elongation after final seating	± 1/2"
Position of deflection points for deflected strands	5% of beam span toward end of beam
Position of handling devices	±6"
Bearing plates (ctr. to end of beam)	±3/8"
Side inserts (ctr. to ctr and ctr. to end)	±1/2"
Exposed beam ends (deviation from square or designated skew)	
Horizontal	±1/4"
Vertical	±1/8" per foot of beam depth
Bearing area deviation from plane	±1/16"
Stirrup bars (longitudinal spacing)	±1"
Position of post tensioning duct	±1/4"
Position of weld plates	±1"
Elongation (standard gauge length to be a minimum of 20 feet (6 m))	±5%

12

Steel
Reinforcement

1

Discussion Topics

- Steel Reinforcement Characteristics
- Buy America Requirements (Materials IM 107)
- Plan Interpretation
- Reinforcing Steel Placement
- Welding of Reinforcement
- Substitutions

2

What Does Steel Reinforcement Do?

- Steel reinforcement in prestress concrete units provides the tensile strength in the concrete unit.
- Concrete is very poor in tension
- Thermal expansive coefficient of concrete and steel almost identical

3

- AASHTO Grades of Rebar:
  - AASHTO M 31-06 (2006)
    - Grade 40 – Yield Stress of 40,000 psi
    - Grade 60 – Yield Stress of 60,000 psi
    - Grade 75 – Yield Stress of 75,000 psi
- In General, Iowa DOT Designs use Grade 60 Steel Reinforcement

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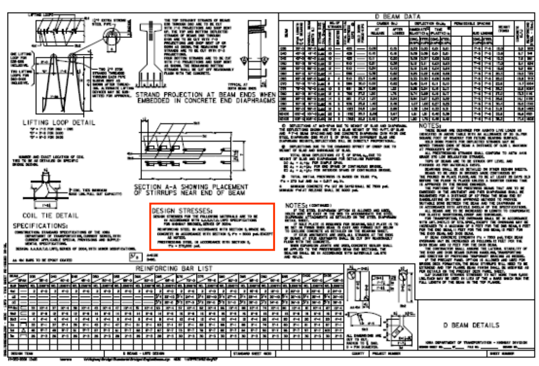

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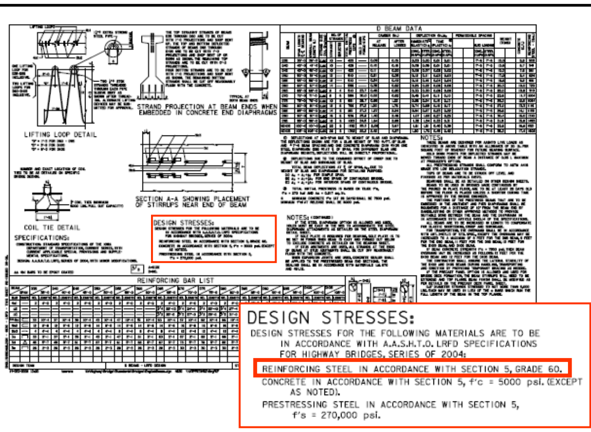

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Size of Reinforcing Bars

- English Units

  Size Number = Diameter in 1/8" Increments

  Sizes vary from #3 to #18 bars

7

ASTM A615 CHART FOR REINFORCING STEEL BARS

Inch-Pound Bar Size Designation	Nominal Weight lb./ft.	(kg/m)	Nominal Dimensions: Diameter in.	(mm)	Cross Sectional Area in^2	(mm^2)
#3	0.376	(.560)	0.375	(9.5)	0.11	(71)
#4	0.668	(.994)	0.500	(12.7)	0.20	(129)
#5	1.043	(1.552)	0.625	(15.9)	0.31	(200)
#6	1.502	(2.235)	0.750	(19.1)	0.44	(284)
#7	2.044	(3.042)	0.875	(22.2)	0.60	(387)
#8	2.670	(3.974)	1.000	(25.4)	0.79	(510)
#9	3.400	(5.060)	1.128	(28.7)	1.00	(645)
#10	4.303	(6.404)	1.270	(32.3)	1.27	(819)
#11	5.313	(7.907)	1.410	(35.8)	1.56	(1006)
#14	7.65	(11.39)	1.693	(43.0)	2.25	(1452)
#18	13.60	(20.24)	2.257	(57.3)	4.00	(2581)

8

Acceptance of Rebar

Materials IM 204, Appendix Z:

- Approved Source per IM 451
- Mill Certifications
  - Physical Tests
  - Chemical Tests
- Epoxy Certification/Test Report
- "Buy America" requirements apply!

9

Buy America

Article 1107.06:

"On all contracts, all products of iron, steel, or a coating of steel which are incorporated into the work shall be of domestic origin and shall be melted and manufactured in the United States."

Includes steel materials incorporated into prestressed units

10

Standard Specification 1107.06

B. Buy America.

On all contracts, all products of iron, steel, or a coating of steel which are incorporated into the work shall be of domestic origin and shall be melted and manufactured in the United States. The Engineer may allow minimal amounts of these materials from foreign sources, provided the cost does not exceed 0.1% of the contract sum or $2,500, whichever is greater. This amount shall include transportation, assembly, and testing as delivered cost of foreign products to the project.

11

I.M. 107

PRODUCTS SUBJECT TO BUY AMERICA

Group 1 – Products requiring mill test reports with shipments to projects

Group 2 – Products not requiring mill test reports with shipments to projects, when the product is from an approved fabricator

12

Group 1 – Products requiring mill test reports

- **Steel Reinforcement**
- Galvanized Steel Bars
- **Epoxy-Coated Steel Reinforcement**
- Deformed and Plain Stainless Steel Bars for Concrete Reinforcement
- High Strength Fasteners
- Stainless Steel Fasteners
- Anchor Bolts
- Steel Piles
- Steel H-Piles
- Steel Sheet Piles
- Steel Pipe Piles
- Pile Points for Steel H-Piles

13

Group 2 – Products not requiring mill test reports

- Truncated Domes/Detectable Warning Systems
- Corrugated Metal Culvert Pipe
- Rodent Guards
- Safety Grates
- Corrugated Zinc-Coated Steel Plates for Pipes & Arches
- Precast Concrete
- Concrete Pipe & Special Sections
- Precast Box Culverts
- Mechanically-Stabilized Earth (MSE) Retaining Wall Panels
- Precast Concrete Noise Walls
- Utility Access Adjustment Rings
- Reinforcing Steel Supports

14

Group 2 – Products not requiring mill test reports

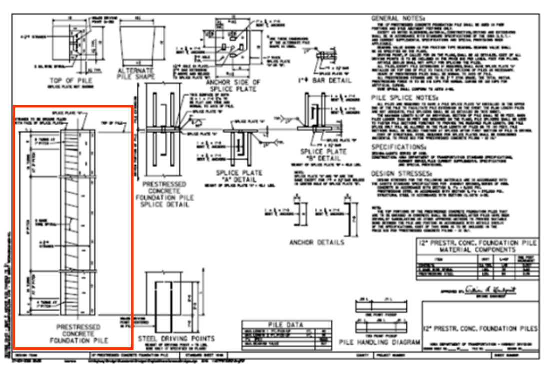
- Steel Castings (Carbon), Gray Iron Castings, and Ductile Iron Castings
- Concrete Anchors
- Shear Stud Connectors
- Chain-Link Fence and Field Fence
- High Tension Cable Guardrail
- Formed Steel Beam Railing, Cable Rail, Anchor Cable & Steel Post for Guardrail
- Rigid Steel Conduit
- Perforated Square Steel
- **Precast & Prestressed Concrete Bridge Units**
- Precast Concrete Barrier

15

Prestress Concrete Piling

- Details identified in Standard Plans.
- Reinforcing is usually 5 gauge wire spirals.
- Pitch is indicated on plan sheet.

16



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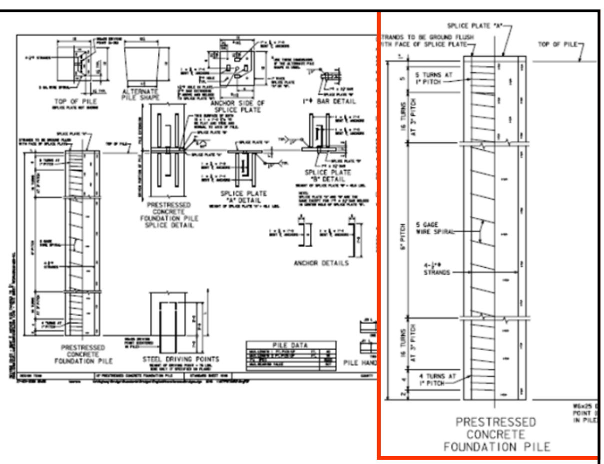

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Field Bending of Reinforcing Steel

- Reinforcing steel that is field bent should be bent strictly in accordance with the plan details.
- Steel reinforcing shall be bent cold – no external heating to ease bending.
- Special care should be taken to bend bars at the proper radius.

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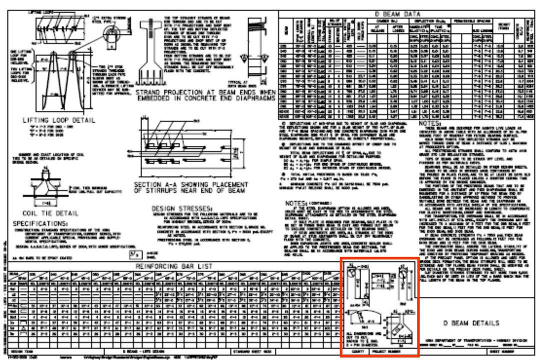

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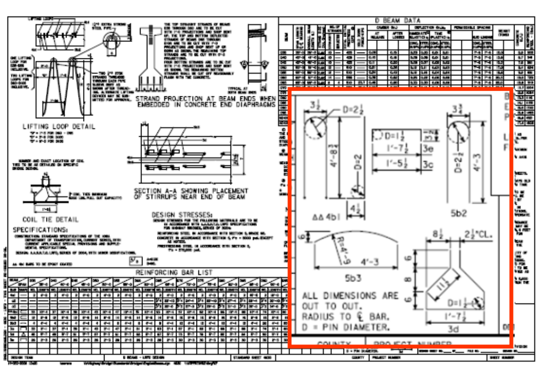
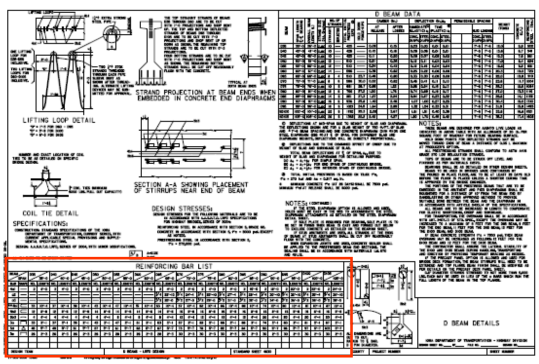


21

Placement of Reinforcing Steel

- Beam Standard Plan Sheets show placement details for reinforcing steel.
- Most Prestress Plants generate "fabrication drawings" or "pour packs", for use by fabrication and QC staff.
- These drawings are based off the Beam Standard Plans.

22



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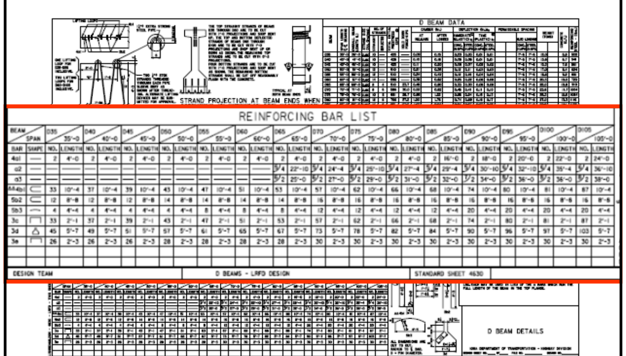
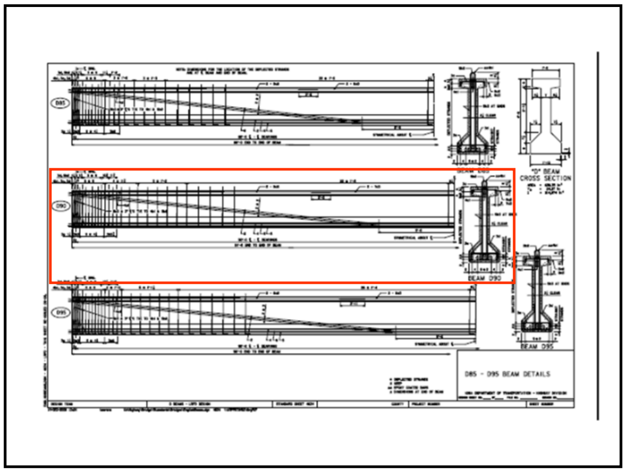


REINFORCING BAR LIST

BEAM / SPAN		D35 35'-0		D40 40'-0		D45 45'-0		D50 50'-0		D55 55'-0		D60 60'-0		D65 65'-0		D70 70'-0		D75 75'-0		D80 80'-0		D85 85'-0		D90 90'-0		D95 95'-0		D100 100'-0		D105 105'-0	
BAR	SHAPE	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH
4a1	—	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	4'-0	2	16'-0	2	18'-0	2	20'-0	2	22'-0	2	24'-0
a2	—	—	—	—	—	—	—	—	—	—	—	—	—	5/4	22'-10	5/4	24'-4	5/4	25'-10	5/4	27'-4	5/4	29'-4	5/4	30'-10	5/4	32'-10	5/4	35'-4	5/4	36'-10
a3	—	—	—	—	—	—	—	—	—	—	—	—	—	5/2	25'-0	5/2	27'-0	5/2	29'-0	5/2	31'-0	5/2	32'-0	5/2	34'-0	5/2	36'-0	5/2	36'-0	5/2	38'-0
4b1		33	10'-4	37	10'-4	39	10'-4	43	10'-4	47	10'-4	51	10'-4	53	10'-4	57	10'-4	62	10'-4	66	10'-4	68	10'-4	74	10'-4	80	10'-4	81	10'-4	87	10'-4
5b2		12	8'-8	12	8'-8	12	8'-8	14	8'-8	14	8'-8	14	8'-8	14	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8	16	8'-8
5b3		4	4'-4	4	4'-4	4	4'-4	4	4'-4	8	4'-4	8	4'-4	8	4'-4	12	4'-4	12	4'-4	12	4'-4	12	4'-4	20	4'-4	20	4'-4	20	4'-4	20	4'-4
3c		33	2'-1	37	2'-1	39	2'-1	43	2'-1	47	2'-1	51	2'-1	53	2'-1	57	2'-1	62	2'-1	66	2'-1	68	2'-1	74	2'-1	80	2'-1	81	2'-1	87	2'-1
3d		45	5'-7	49	5'-7	51	5'-7	57	5'-7	61	5'-7	65	5'-7	67	5'-7	73	5'-7	78	5'-7	82	5'-7	84	5'-7	90	5'-7	96	5'-7	97	5'-7	103	5'-7
3e		26	2'-3	26	2'-3	26	2'-3	28	2'-3	28	2'-3	28	2'-3	28	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3	30	2'-3

DESIGN TEAM | D BEAMS - LRFD DESIGN | STANDARD SHEET 4630

24



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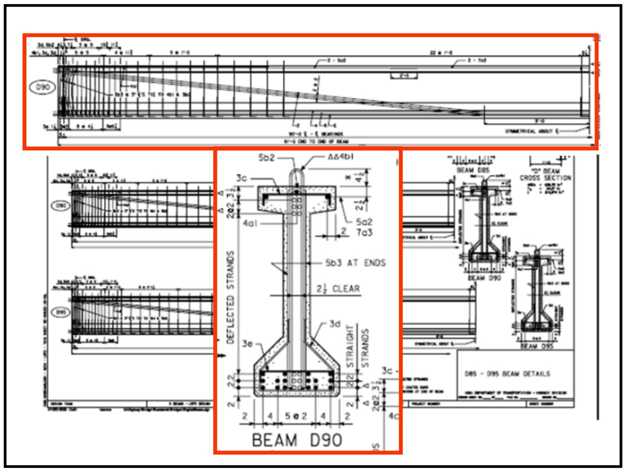


26

Placement of Reinforcing Steel

Steel Reinforcement must be secured adequately (Article 2404.03D)

- Spacing of bars greater than 12” c-c shall be tied at each intersection.
- Spacing of bars less than 12” c-c shall be tied at every other intersection.

27

Tolerances of Placement

- Reinforcing shall be fabricated within tolerances noted in Articles 2404.03D and 2407.03J2:
  - Must be in the position indicated on the contract documents
  - Stirrup bars tolerances (2407.03J2):
    - Project above top of beam +1/4” or –3/4”
    - Longitudinal spacing ± 1”

28

Bar Splicing

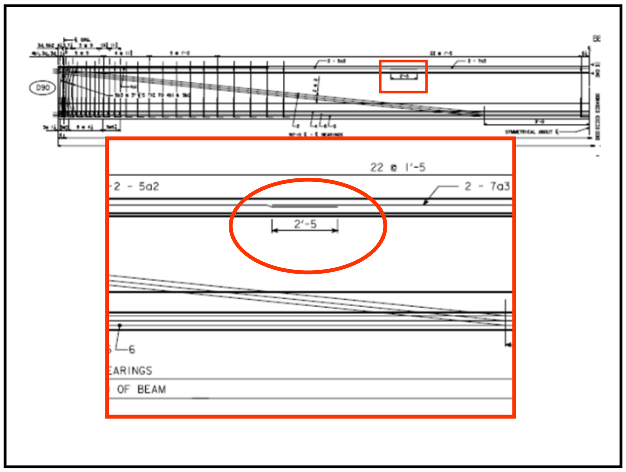
- Bar splicing sometimes required when continuous reinforcement required throughout length of beam.
- Standard Plans show required splice lap and location of splice.
- Variations only as approved by the Engineer.

29

Bar Splicing

- Bars must be spliced at location identified on plan.
- Bars must have at least the minimum overlap, as noted on the plans.
- Bars must be in close contact.
- Bars must be wired tightly together.

30



31

Mechanical Bar Splicing

- Mechanical Bar Splicing is permitted.
- Mechanical splicers must be from Approved List in Materials IM 451, Appendix E.

32

Tack Welding of Reinforcing Steel

- Uncoated steel reinforcing bars may be fastened together by the use of tack welding (in lieu of tie wire).
- Tack welding must be performed by an Iowa DOT Certified Welder, in accordance with Article 2407.03E2) and AWS D1.4.

33

Tack Welding of Reinforcing Steel

- Tack welds should only be strong enough to keep bars from separating.
- Tack welds should be periodically tested by dropping assembly to verify that weld breaks.
- Tack welds should not penetrate into the reinforcing bar.

34

Substitution of Reinforcing Bars

- At the Fabricator's choice, the top longitudinal reinforcing bars may be replaced with prestressing strands.
- Maximum prestressing permitted for these strands is 5000 pounds (5 kips).

35

Substitution of Reinforcing Bars

- Fabricator may substitute larger reinforcing bars (one size larger than indicated on the plans).
- Evaluate the concrete clearance of the larger bars to assure compliance.
- Substitution of larger bars done at no cost to the Contracting Authority.

36

Any Questions?

37

Pre-Pour Inspection

1

- Pre pour guide IM 570
- Pre-pour inspection starts prior to bed setup with assurance that all materials to be incorporated have been approved.
  - Identify & document materials requiring outside fabrication inspection.
  - Verify that all materials incorporated meet the requirements of the contract documents
- Bed setup
  - Pallet joint, cleanliness, holddown/holdup locations, proper number and position of strands, strand to pallet alignment
  - Straight and level
  - Pallet oiled, no rust, no concrete
  - No holes, gaps and any other deformities

2

- Strand chuck inspection
- Tensioning calculations checked for accuracy
- Steel placement
  - Securely tied
  - Insert and coil tie locations, sole plates, steel placements Check Strand position

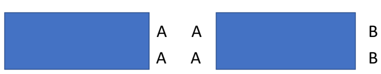
3

- Forms
  - Proper alignment (checked with stringline)
  - Good condition
    - Holes
    - Dents
    - Rust
  - Secured into place
  - Horizontal and vertical alignment
  - Depth and width
  - Properly stored when not using
  - Forms aligned with each other and meet specifications, no gaps that will cause bleedout.
  - Joints are even and meet specifications

4

- Check for length and width (unless noted on the plans, all beams shall be cast with an increase in length of (0.0005 x L) (where L is the length of beam) to compensate for elastic shortening, creep, and shrinkage

- Need to have some type of system in place to know which forms go together better.



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6

Concrete Mixtures

1

Concrete for Prestressed Units

- High early strength concrete mixtures preferred by Producer
- Allow for rapid turning of beds
- Generally higher cement content
- Limited use of supplementary cementitious materials

2

Concrete for Prestressed Units

- Generally higher compressive strengths required as compared to "cookbook" concrete mixtures
- Mixes are specialized and site specific mix designs are generally utilized

3

Article 2407.02

- Concrete Materials Requirements for Prestressed Units
  - Aggregates
  - Portland Cement
  - Supplementary Cementitious Materials
  - Admixtures

4

Aggregates

- Meet the requirements of Articles 4110, 4111, and 4115, except for gradation requirements
- Class 3 durability or better required
- Approved concrete sand

5

Portland Cement

- Article 4101 applies
- Type III cement may be permitted, if approved
- Total equivalent Sodium Oxide between 0.61% and 0.75% permissible if non-reactive with aggregates in the mix

6

Supplementary Cementitious Materials

- May be used at following maximum substitution rates:
  - Fly Ash alone: 25% max
  - Ground Granulated Blast Furnace Slag (GGBFS) alone: 35% max
  - Combination of Fly Ash and GGBFS: 50% combined total max

7

Admixtures

- When authorized by the Engineer, approved admixtures complying with Article 4103 may be used.
- Materials IM 403 and its appendices address concrete admixtures
- Appendix H lists prestress plant-specific admixtures

8

High Performance Concrete Mixtures (HPC)

- Required for LRFD beam
- Mix design approval required:
  - Meet requirements of ASTM C 1202
  - 1500 coulombs or less (low permeability)
  - If silica fume, Class F fly ash, or GGBFS used, may waive ASTM C 1202 testing

9

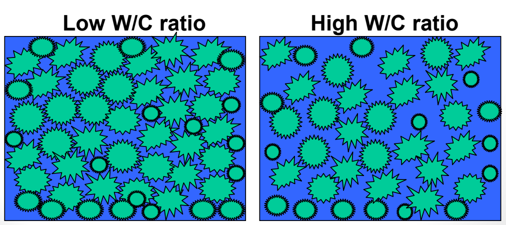
Water To Cementitious Ratio

- Important mix design consideration
- $\frac{W}{C}\ ratio = \frac{total\ weight\ of\ water\ in\ mix\ (lbs)}{total\ cementitous\ weight\ (lbs)}$
- Total water includes all water added at all stages and accounts for water contributed or absorbed by aggregate
- 1 gallon of water weighs 8.33 lbs
- Significantly impacts strength and permeability
- Minimize while providing adequate workability
- Maximum of 0.450
- Slump is an indicator of workability

10

Low To High

- Excessive water increases void space between hydration products creating concrete that has lower strength and higher permeability



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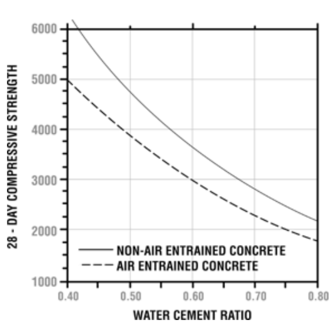
Relationship To Strength



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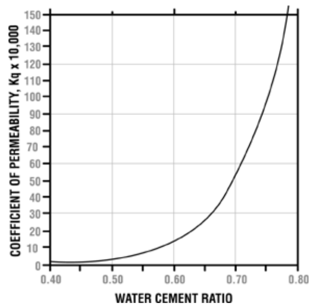
Relationship To Permeability



13

Water To Cementitious Ratio

Example 1

The mix has the following batch weights what is the w/c ratio?

- 600 lbs/yd^3 cement
- 225 lbs/yd^3 water

W/C Ratio= $\dfrac{\textit{Total Weight of water in the mix (lbs.)}}{\textit{Total Weight of Cementitous material (lbs)}}$

W/C Ratio $\dfrac{225 \text{ lbs/yd}^3}{600 \text{ lbs/yd}^3} = 0.375$

14

Water To Cementitious Ratio

Example 2

The mix has the following batch weights what is the w/c ratio?

- 580 lbs/yd^3 cement
- 80 lbs/yd^3 fly ash
- 210 lbs/yd^3 water
- 5 gallons water added

W/C ratio= = 0.381

15

Water To Cementitious Ratio
Example 2

The mix has the following batch weights what is the w/c ratio?

- 580 lbs/yd^3 cement
- 80 lbs/yd^3 fly ash
- 210 lbs/yd^3 water
- 5 gallons water added

W/C ratio= $$\frac{210\ \text{lbs/yd}^3 + (5\ \text{gal} * 8.33\ \text{lbs/gal})}{580\ \text{lbs/yd}^3 + 80\ \text{lbs/yd}^3} = 0.381$$

16

Strength

- Compressive testing by producer
- Design is based on a minimum strength
- Different beams have different minimum strengths
- Strengths vary for de-tensioning and shipping
- Representative samples with representative treatment

17

Factors Controlling Strength

- W/C ratio
- Cementitious material
- Aggregate strength and texture
- Air content
- Curing
- Age

18

Permeability

- Permeability testing on select projects by Iowa DOT
- Maximum permeability of 2500 coulombs
- Important when moisture and chloride laden water may exist
- Representative samples with representative treatment

19

Factors Controlling Permeability

- W/C ratio
- Cementitious material
- Curing
- Age

20

Mix Design

- Responsibility of producer
- Use
  - Absolute volumes
  - SSD moisture conditions
  - Approved materials
- Must be approved by the DME
- Field checked using representative conditions
- DME should be notified of substantial changes
- TTCP Level II & III PCC technician training encouraged but not required

21

Batching

- Done by weight
- Representative of mix design
- Batching equipment
  - Automatic - powered and computer controlled
  - Semi-automatic - powered but operator controlled
  - Manual - operator controlled
- Plant calibration at least once a year
- Plant calibration requirements are detailed in Article 2001.20 of Standard Specifications and I.M. 527 and 528
- Develop and maintain an appropriate batching sequence

22

Mixing

- Central
  - Mixed in permanently mounted mixer/agitator drum
  - 1 to 5 minutes time limit
  - Comply with recommended speed and capacity
- Ready Mix
  - Truck mixed
  - 60 to 90 revolutions w/preblending
  - 70 to 90 revolutions w/o preblending
  - Each truck checked every 30 days
  - Comply with recommended speed and capacity

23

Transport

- Non-agitating
  - 30 minutes of discharge from central mixer
- Agitating
  - 90 minutes from water and cement contact
- Interval between delivered batches shall not exceed 45 minutes
- Mix properties may govern transport time

24

Consolidation

- Provide uniformly dense and closed concrete
- Vibration
  - External
  - Internal
- Considerations
  - Overlap influence zones (vertical and horizontal)
  - Provide adequate
  - Avoid excessive

25

Curing

- Provide environment to allow hydration to continue
- Heat
  - None
    - Slower strength gains
    - Prevent moisture loss
    - Must maintain 40°F minimum
  - Artificial
    - Faster strength gains
    - Concrete temperatures requirements
      - Not raised above 100°F for at least two hours after casting
      - Raised at a rate not to exceed 25°F per hour to a maximum of 160°F
      - Lowered at a rate not to exceed 40°F per hour until reaching ambient
      - Not vary by more than 40°F throughout bed during the curing period

26

Self Consolidating Concrete

- Permitted for use in prestressed beams in Iowa
- Little to no vibration
- Better finish
- Highly flowable mix uses:
  - Increased fine materials (cement, fly ash, slag, and limestone fines)
  - Viscosity Modifying Admixture (VMA)
  - Combination of increased fines and VMA

27

Self Consolidating Concrete

- Mix design approval per IM 445 Appendix D
- Slump Flow (spread) and Visual Stability Index per IM 389
- Static Segregation of Hardened SCC Cylinders per IM 390
- Placement technique is critical
- Gradation is critical
- Moisture is critical
- More mix design and quality control testing

28

Concrete Strengths

1

Test Specimens

- I.M. 327
- Describes Sampling
  - Should be representative of the entire batch

- I.M. 315
  - Making Cylinders
    - Making, Curing, Testing
    - Specimen sizes 4x8 amd 6x12 vertical molds
    - Tested by capping ends or using neoprene pads

2

Want to make 3-4 sets of cylinders for a line

- If you break a set for release or shipping and the average comes in short of what is required, you will have to break another set.
- Remember, you want to keep the cylinders in a moist condition right up to when you break them.
  - Don't take them out of water and sit for any length of time, break them immediately.

3

- Must achieve minimum specified compressive strengths to withstand the prestressing forces to be applied to the unit and later stresses induced during shipping.
- Where would you find the specified strengths?
  - Beam Standards
  - 2407.03 standard specifications
  - Special notes in the project plans

4

- Typically smaller girders
  - 4500 lbs release strength
  - 5000 lbs shipping strength (28 day strength)
- Longer girders
  - 6000 or 7000 lbs release strength
  - 7500 or 8500 lbs shipping strength (28 day strength)

5

- Release Strength is when you can detention the line
  - f'ci = Release Strength
  - Do not have to achieve release strength to remove forms
  - If there is damage or strand is showing when remove forms, do not detention. You need to contact your QA (dot plant monitor) inspector **BEFORE** you detension that line

6

- f'c = 28 day Strength or Shipping Strength
  - Release and 28 Day Strength may be the Same
- Beams need to be at least 14 Days old in Age before they can be shipped to project
- **CAN NOT** place Concrete Deck until the Beams have reached 28 Days in Age.
  - May Place and tie Deck Steel

7

Sure Cure Cylinder Molds

8

Curing Specimens

- Cure in similar manner as concrete on the line is being cured
  - Curing Chambers (Sure cure System)
    - Duplicates the internal temperature of the concrete units during the curing time
  - Curing on the Line
    - Not exposed directly to live steam
    - Specimens cured near the top of the unit or at least mid-way up the forms

9

Determining Strength for a Line

- A set of cylinders is three(3) specimens, each representing a portion of the casting bed (both ends and the center of the line casted)
- For release and shipping (28 day) strengths
  - The average strength of the specimens tested is equal to or greater than the minimum compressive strength required AND
  - No individual cylinder of the set tested has a compressive strength less than 95% of the required strength
  - If both conditions are NOT met after an appropriate curing time, another set shall be tested

10

CLASS EXAMPLE #1

- The Required Strength is 4500 PSI
- The Cylinders are Tested
  - 4750 PSI
  - 4850 PSI
  - 4930 PSI

11

Example #1 Condition #1

- Average of the 3 specimens
  - 4750
  - 4850
  - <u>4930</u> (add the 3 lines)
  - 14,530 total PSI (divide by 3 to get average)
  - 14,530 PSI/3 = 4843 PSI (average of 3 specimens)
    - Required Strength = 4500 PSI

The Average Strength of the Specimens Tested is Equal to or Greater than the Minimum Compressive Strength Required.

12

Example #1 Condition #2

- 95% of 4500 PSI =
- 4500 x .95 = 4275 PSI

Individual Cylinders

4750 PSI

4850 PSI

4930 PSI

No Individual Cylinder of the Set Tested has a Compressive Strength Less Than 95% of the Required Strength

13

- Example #2
- Required Strength 8000 PSI
- Individual Cylinders
  - 7809 PSI
  - 8215 PSI
  - 8450 PSI

14

Example #2 Condition #1

7809 PSI
8215 PSI
+8450 PSI
24,474 PSI 24,474/3 = 8158 PSI Average
8000 PSI Required Strength

Is this in-compliance with Condition #1?

Condition #1: The Average Strenth of the Specimen Tested is equal to or Greater than the Minimum Compressive Strength Required.

15

Example #2 Condition #2

- 95% of 8000 PSI (required strength)
- 8000 x .95 = 7600 PSI

Individual Cylinders

7809

8215

8450

- Is this in-compliance with condition #2?

No Induvial cylinder of the set tested has a compressive strength less than 95% of the Required Strength.

16

Detensioning

1

- Prestress transfer means releasing the tensioned strands held by the abutments or self stressing bed.
- This causes the strand to impose prestressing forces within the precast and prestressed concrete unit.
- Shall not be transferred to the cast units until the concrete compressive strength, as indicated by concrete cylinders, has achieved the specified release strengths.
- Should be performed by experienced personnel.
- Certain procedures must be followed and these methods are to be included in the plant procedures manual.

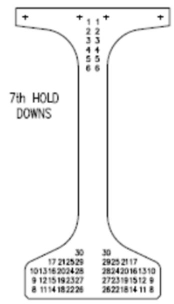
2

- If concrete has been cured using accelerated heat curing:
  - ✓Prestress transfer shall be performed immediately following the curing period while concrete is still warm and moist.

3

Straight Strand, Single Strand Detensioning

- Both ends of casting bed released simultaneously and systematically, by flame cutting, to minimize sliding of members.
- Strands are not to be released one at a time with a jack
- Approved pattern (that keeps stresses nearly symmetrical about the vertical axis of the member.
- Strands shall not be cut quickly, release gradually (heated until the strand gradually loses its strength)
- Coordinated between workers (watching each other)
- May require de-tensioning at several points in the bed, as well as at the ends to avoid sliding and or damage to the un or the bed.



4

Straight Strand Multiple Strand De-Tensioning

- Strands are released simultaneously by hydraulic jacking where the total force is taken from the header by the jack, then released gradually.

5

Draped Strand De-Tensioning

- Forms removed
- Draped strand released first
- Hold-up devices at beam ends may be lowered simultaneously as practical. If not feasible, draped strands may be flame cut in each beam interval, in rotation until all draped strands are released.

6

De-Tensioning Review

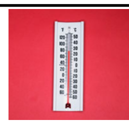
- Draped strands first by cutting the same two strands at a time at each interval until the strands have been cut at each end of each beam. Cutting progression should start at one end and proceed to the other. The next two strands should be cut in the same manner and continue until all of the draped strands have been cut.
- When cutting strands with a torch, the first wire should break no less than five seconds after the strand has been exposed to the heat.
- After draped strands have been cut, the hold-downs bolts are removed.
- Then the bottom strands shall be detensioned, either by cutting or by releasing the pressure on the multi-pull ram.

7

Post Pour Inspection

1

Monitoring Cure Temperatures
(If using artificial Cure)



Do not exceed 100 degrees until at least 2 hours after units have been casted.

Maximum temperature is 155 degrees at a rate not to exceed 25 degrees per hour.

Concrete temp in casting bed has a 40 degree range.

Concrete temp shall not be lowered at a rate not to exceed 40 degrees per hour until it reaches air temp.

The concrete shall be covered and remain covered until curing is complete.

2

Post pour inspection for any possible product deficiencies should be made as soon as practical after forms are removed.

Identify and store cylinders with the respective units.

Ensure proper cylinder cure (remain moist through the testing process).

Check temperature and record during curing process.

Check unit for defects and obtain approval for repairs.

Ensure concrete strength has been met prior to releasing the line.

Ensure proper detensioning procedures are followed.

3

Measure and record camber at release and compare to design camber Measure and record overall dimensions of beam.

Check beam ends for fabrication in accordance with the plans.

Ensure exterior sides of facia beams are grouted.

Check and/or measure and record lateral sweep before shipping.

Honeycomb and surface defects shall be filled and finished.

Bugholes smaller than ½" in diameter need not to be filled in unless it is in a concentrated form.

4

Each unit must have legible identification displayed on the web.

Identification shall include: Producer's name, beam number, fabrication date, and facia girder identification.

Beam Number in center of beam for Bridge Beam Information System (BRIS) page.

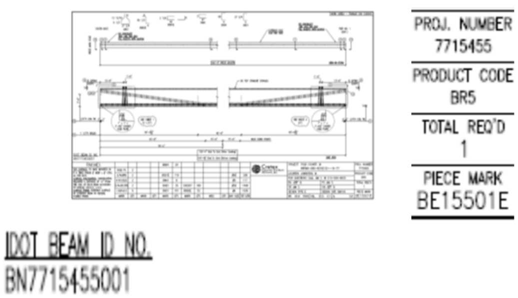
When required by the plans, beam-ends shall be coated and sealed at the plant with an approved epoxy listed in IM 491.19 appendix B.

5

6

7

Bridge Beam Information System



8

Camber IM 570 page 12

Camber Measurement Procedure

Camber due to prestress shall be measured by checking the beam profile immediately (within 3 hours) after detensioning and separation of the beam.

9

The measurement needs to be compared to the design release camber. If the measured camber is different by more than 30% of the design camber, this may be an indication of a future problem with the unit achieving the proper design camber after losses.

Any deficiencies should be documented and called to the attention of the QA inspector. A plan should be developed to determine acceptability of the beam, and also the cause of the discrepancies should be investigated.

10

When the camber of beam or beams is outside the designed camber, or when they are not uniform for a given bridge, the contractor must account for the discrepancies by adjusting grade or form placement, etc.

Beam Camber can be influenced by the following:

Concrete Strength
Storage/Dunnage
Location of prestressing strand
Tensioning (actual prestressing forces)

11

12

13

14

Sweep Measurement

Sweep is defined as the deviation from a straight line parallel to the centerline of the beam(horizontal alignment)

Beams, especially those over 80’ long, must be checked for sweep compliance. The tolerance is L/80, where L is the length of the beam from end-to-end in feet. The result is expressed in inches.

Example#1: BTE155 = 155’ 4’’ ft from end to end
155.33/80 = 1.9” maximum allowed sweep

Example#2: A46 = 47’ 8’’ ft from end to end
47.67/80 = 0.60” maximum allowed sweep

15

Sweep may be caused by several reasons such as:

- Temperature differential between the sides of beam
- Improper application of prestressing forces
- Improper storage
- Bowed forms

Beam Measurement Procedures IM 570 page 14

Measured when the beam is not influenced by any differences in surface temperatures from face-to-face or side-to-side

Should be able to meet the sweep tolerance without any external influence (temp or sun) or any applied forces

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Sweep compliance shall be made no earlier than 48 hours and not until after the sweep correction techniques have been fully completed and the beam has been freed. The beam shall remain straight and must comply with specifications of L/80.

When the beam is completely free, check beam on bed(if possible) lift the beam and resetting it shall be required.

Beams shall be corrected at the plant prior to shipping to the project site.

The fabricator shall tilt or lean the beam, this procedure will not require any prior approval.

Page 15 IM 570 C. A force may be applied to induce a maximum corrective lateral deflection as outline .

Page 16 IM 570 Sweep Correction – Field Procedures.

17

Beam Finishing

Tops of beams:

Facia sides fully grouted

Bug holes filled in

Bottoms fill in hold downs and pallet joints. No rust also

Form Joints need to be checked for tolerance. Grind or fill in with grout

18

Post Pour Repairs

Appendix B in IM 570

The fabricator shall propose repair procedures and list the brand name of patching material and submit his request to the District Materials Engineer .

If beam is at project site, then submit the procedures to the DME in that district.

19

4 Types of Repairs in IM 570

Structural
Cosmetic
Epoxy Injection
Cut off Strands

20

IM 570 appendix F page 1

Principal Factors in Quality Control

21

Prestress Beams Repairs

1

IM Prestress Appendix B Prestressed/Precast Concrete Bridge Units

- Structural Repairs
- Non-Structural Repairs
- Crack Repairs
- Strand Extension Repairs
- Repair Site Containment

2

Structural Repairs, Voids

- Prestressed strand is exposed/not fully encased in concrete
- Must not de-tension strands prior to completing repairs
- Notify District Materials so they may inspect the defect
- Prepare and submit a repair plan for DOT approval
- Follow general procedures outlined in Appendix B

3

Non-Structural Repairs, Voids

- Prestressed strand is not involved; steel reinforcement may or may not be exposed
- Repairs may be performed in the yard after the beam is de-tensioned
- Prepare and submit a repair plan for DOT approval
- Follow general procedures outlined in Appendix B

4

Non-Structural Repairs, Damage

- Very similar to void repairs:
  - Prestressed strand not involved
  - Repairs may be performed in the yard
  - Prepare and submit a repair plan for approval
- Alternate repair materials and methods are common
- Supplementary reinforcement may be necessary

5

6

Cracking in Prestressed Beams

- Like all concrete, prestress concrete will have cracks
- Frequency and severity of cracking depends on beam fabrication practices
- Goal is to reduce the number of cracks, and severity of cracks

7

8

Why worry about cracks?

- Loss of bond between concrete and strand
- Cracks can cause strand fatigue, especially at mid-span
- Cracks are conduit for corrosive agents to attack strands
- Beam appearance is affected

9

Causes of Cracks/Damage

- Concrete shrinkage
- Differential heat of hydration during curing
- De-tensioning procedures
- Improper handling
- Transporting

10

Preventing and Minimizing the Severity of Cracks

- Shrinkage
  - Can't be prevented
  - Minimize severity by keeping water/cement ratio low and consistent
- Curing
  - Increase the steam curing time
  - Lower maximum temperature
  - Slower cooling of concrete

11

Preventing and Minimizing the Severity of Cracks

- De-tensioning
  - Increase the "free length" of strand between beams
  - Include protective sole plates per IM 570 Appendix H and H1
  - Carefully synchronized de-tensioning operations
    - Spec 2407.03H Prestress Transfer
    - IM 570 Debonded Prestressing Strands
    - Beam- and plant-specific production drawings

12

Preventing and Minimizing the Severity of Cracks

- Improper Handling
  - Careful form removal
  - Careful lifting from the bed, moving to the yard, and setting on dunnage
- Transporting
  - Careful lifting in the yard, loading, and securing on the trailer
    - IM 570 Appendix J Optional Shipping Tie Down Holes
  - Careful over-the-road travel and unloading at the project site

13

Preventing and Minimizing the Severity of Cracks

"Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns"
(article from PCI Journal in reference section)

14

Repair of Cracks

- Some cracks need no repair
  - Filled by standard finishing procedures
  - Embedded in pier or abutment concrete
  - Close when the beam is loaded
    - Under its own weight during transport in the yard
    - Under deck weight at the project site
- Repair by Epoxy Injection
  - Use approved material per IM 491.19 Appendix B
  - Surface injection or drilled port injection

15

Strand Extension Repairs

- Strand may be:
  - Cut off flush with the beam ends
  - Cut off to a specific length
  - Cut off to length and bent
- Strand improperly cut may be repaired by:
  - Properly cutting/bending an adjacent strand
    - Must be an adjacent strand
    - Must maintain vertical symmetry of strand pattern
  - Follow general procedures outlined in Appendix B

16

Repair Site Containment

- Intended to reduce chance for dislodged repair material to fall and cause damage
- All spall and void repair sites shall be reviewed by District Materials for possible containment measures. Review includes:
  - Location of repair site on beam
  - Location of beam in bridge
  - Location of key features under bridge:
    - Roadways
    - Railroads
    - Other

17

Repair Site Containment

- Measures are intended to contain possible debris; load-carrying capacity of the beam is not affected
- Use approved Fiber Reinforced Polymer (FRP) system per IM 491.25 Appendix A
- Follow general procedures in Appendix B

18

Final Inspection
Checklist

1

Nonconformances

Bottoms

Form Joints

Top

Sides

Chamfer

Ends

Inserts

2

Nonconformances
- All nonconforming tags have been removed and items fixed

Bottoms
- Pallet joints
- Holddowns holes filled
- Straight bottom
- Pintles clean
- End plates clean

Form Joints
- Joints meet specifications
- Allign correctly
- No bleedouts

Top
- All debris has been swept off or removed

Sides
- Finish Meets specifications pertaining to bugholes, bleedouts, spalls, no wire tires are visible

3

Chamfer

- Chamfer straight and meets specifications pertaining to bleedouts
- Bugholes

Ends

- Straight
- No rebar showing
- No bleedouts
- No spalls
- Strand bent and/or cut off as required
- Epoxied if required

Inserts

- Inserts not skewed
- Present & clean

4

Decimal to 1/8 inch		
From	To	1/8" fraction
0.9376	0.0625	0/8
0.0626	0.1875	1/8
0.1876	0.3125	2/8
0.3126	0.4375	3/8
0.4376	0.5625	4/8
0.5626	0.6875	5/8
0.6876	0.8125	6/8
0.8126	0.9375	7/8

Precast Prestressed Bridge Units.
Limit variation from dimensions shown in the contract documents to the tolerances shown in Table 2407.03-3:

Table 2407.03-3: Tolerances

Length	±1/4" per 25' and ±1" max. for beams 100' or longer
Width (flanges and fillets)	+3/8" or -1/4"
Depth (overall)	+1/2" or -1/4"
Width (web)	+3/8" or -1/4"
Depth (flanges and fillets)	±1/4"
Bearing plates (ctr. to ctr.)	1/8" per 10' of beam length, max. ±3/4"
Sweep (deviations from straight line parallel to center line of member)	L/80 (L in feet, sweep is in inches)
Camber deviation from design camber	±30% of plan camber
Stirrup bars (project above top of beam)	+1/4" or -3/4"
Individual tendon position	
Straight strands	±1/4"
Draped strands at end of beam	±1/2"
Tendon position	
Center of gravity of strand group	±1/4"
Center of gravity of depressed strand group at end of beam	±1"
Deviation from net theoretical elongation after final seating	± 1/2"
Position of deflection points for deflected strands	5% of beam span toward end of beam
Position of handling devices	±6"
Bearing plates (ctr. to end of beam)	±3/8"
Side inserts (ctr. to ctr and ctr. to end)	±1/2"
Exposed beam ends (deviation from square or designated skew)	
Horizontal	±1/4"
Vertical	±1/8" per foot of beam depth
Bearing area deviation from plane	±1/16"
Stirrup bars (longitudinal spacing)	±1"
Position of post tensioning duct	±1/4"
Position of weld plates	±1"
Elongation (standard gauge length to be a minimum of 20 feet (6 m))	±5%

Section 2407. Precast and Prestressed Concrete Bridge Units

2407.01 DESCRIPTION.

A. Provide prestressed and precast concrete bridge units produced in a plant for which equipment, procedures, and quality of concrete have been approved by the Contracting Authority.

B. Provide, or have the fabricator provide, technical personnel experienced and skilled in the application of the prestressing system being used. Ensure technical personnel cooperate fully with the Engineer in all technical aspects of the work.

C. Apply the provisions of this section to production and construction of prestressed precast concrete bridge units and nonprestressed precast concrete bridge units.

D. Unless modified elsewhere in the contract documents, all fabrication is required to be done only in precast fabrication plants that are approved prior to the letting as per Materials I.M. 570.

2407.02 MATERIALS.

Use materials in prestressed and precast concrete meeting the requirements of Division 41 for the respective material, and the following:

A. Aggregates.

1. Apply Sections 4110, 4111, and 4115, except the gradation requirements of Articles 4110.02, 4111.02, and 4115.03. If high performance concrete (HPC) is being used for prestressed concrete beams, use a coarse aggregate consisting of crushed limestone, quartzite, or granite meeting class 3 durability or better.

2. Submit aggregate gradations and proportions with the mix design to the District Materials Engineer for approval.

3. Use aggregates similar to Class V only when 30% or more of the total weight of aggregate is limestone.

B. Admixtures.
When authorized by the Engineer, approved admixtures complying with Section 4103 may be used.

C. Steel for Prestressing.
Apply Article 4151.05.

D. Reinforcement.
Apply Article 4151.03.

E. Steel Sole and Masonry Plates.
Apply Section 2508 and Articles 2408.03, B, 2408.03, E, and 4152.02.

F. Neoprene Bearing Pads.
Apply Article 4195.02.

G. Bolts and Other Metal Fastenings.

1. Unless indicated otherwise in the contract documents, use non-high-strength fasteners meeting requirements of Article 4153.06.

2. For other fastenings use structural steel meeting the requirements of Article 4152.02, except for anchors and ties for diaphragm connections and hold down devices for deflected tendons. These items will generally be proprietary products and will require the Engineer's approval. The Engineer will approve only those samples that show an ultimate strength of 50% in excess of the manufacturer's advertised safe loads. Use fastenings that are of a type to be cast in the concrete.

3. Use bolts, nuts, washers, and other metal fastenings that have been galvanized as specified for steel structures in Article 4100.07.

H. Cement.
Apply Section 4101, unless otherwise specified. If the use of Type III Portland cement has been authorized, use it in the same proportions as specified for Type I Portland cement. Cement with total equivalent sodium oxide between 0.61% and 0.75% may be used, provided it is non-reactive with the proposed aggregate when tested according to ASTM C 1260, C 1567, or C 1293.

I. Supplementary Cementitious Materials.

1. Apply Section 4108.

2. Fly ash may be substituted for Portland cement. Use a substitution rate of no more than 25% by weight

3. GGBFS may substituted for Portland cement. Use a substitution rate of no more than 35% by weight for GGBFS as a mineral admixture.

4. The maximum total supplementary cementitious materials substitution shall not exceed 50%.

2407.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following:

1. **Casting Beds.**
   a. For precast concrete and prestressed concrete, use casting beds rigidly constructed and supported so that under the weight (mass) of the concrete and the vertical reactions of holdups and hold downs there will be no vertical deformation of the bed.
   b. For pretensioned work use end anchorages, whether self anchored or supported horizontally by the bed, capable of resisting the maximum prestress force to which they will be subjected without permanent displacement.

2. **Forms.**
   a. Use forms for precast and prestressed concrete true to the dimensions as shown in the contract documents, true to line, mortar tight, and of sufficient rigidity to not sag or bulge out of shape under placement and vibration of concrete. Ensure inside surfaces are smooth and free of any projections, indentations, or offsets that might restrict differential movements of forms and concrete.
   b. On long beds for multiple pretensioned beam production where continuous forms and pallets are used, take necessary precautions to prevent damage to the beams from differential movements of forms and concrete due to temperature changes.

3. **Stressing Equipment.**
   a. To tension tendons, use equipment of a type so the prestressing force may be accurately known. Use load cells, dynamometers, and hydraulic gages of hydraulic pump and jacking systems capable of measuring the force applied to the tendons within 2% of the actual force. Calibrate this equipment at least once every 12 months or anytime the tensioning system indicates erratic results. Calibrate hydraulic gages, pumps, hoses and connections as a system.
   b. Perform all tensioning equipment calibrations using load cells calibrated by a testing laboratory or calibration service. For calibration purposes use equipment that has current calibration references. Allow the Engineer the opportunity to witness calibration of equipment during the Engineer's normal working hours or at a mutual agreeable time.

4. **Weighing and Proportioning Equipment.**
   Apply Article 2001.20, except that a vibrator will not be required on the cement batch hopper.

5. **Mixing Equipment.**
   Apply Article 2001.21.

6. **Bins.**
   Apply Article 2001.06.

B. Concrete.

1. For precast and prestressed construction, use at least than 610 pounds of total cementitious material per cubic yard of concrete. Do not exceed the maximum water-cementitious ratio, including free moisture in the aggregate, of 0.450 pound per pound.

2. If the units will form curbs or floors of structures, add an approved air-entraining admixture. The intended air entrainment of the finished concrete is 6%. To allow for loss during placement, use a target value of 6.5% for the air content of fresh unvibrated concrete, with a maximum variation of ± 1.0%.

3. Properly proportion, mix, place, and cure concrete within these limits to produce concrete of a minimum compressive strength specified in Table 2407.03-1 at the designated age.

Table 2407.03-1: Concrete Strength

Classification	Concrete Strength Before Moving or Prestressing, psi	Concrete Strength at Age 28 calendar days, psi
Precast Sheet or Bearing Piles	3500	4500
Precast Bridge Deck Units	3500	5000
Prestressed Piles	4000	5000
Prestressed Deck Panels	4000	5000
All Other Prestressed Concrete[a]	4500	5000

[a] Unless noted otherwise in the contract documents.

NOTE: Do not ship beams until the concrete has attained the 28 day strength.

4. If using HPC for prestressed concrete beams, use a mix design that has been evaluated according to ASTM C 1202 or AASHTO T358 and approved by the Engineer. To obtain mix design approval either:
   a. Submit to the Engineer ASTM C 1202 results from mix samples taken and tested by an independent laboratory. The results shall be 1500 coulombs or less when cured using accelerated moist curing.
   b. Submit to the Engineer AASHTO T358 results from mix samples taken and tested by an independent. The results shall be 30 kilohm-cm or more when cured for 28 day moist curing.
   c. Contact the Engineer and arrange for a trial batch. The producer certified technician shall cast 4 inch by 8 inch cylinders for testing by the Materials Laboratory. The AASHTO T358 results shall be 30 kilohm-cm or more on samples moist cured for 28 days.
   d. When a minimum of 20% class F fly ash, or GGBFS, or Type IS or IP cement is used in the mix, the Engineer may waive ASTM C 1202 or AASHTO T358 testing.

C. Proportioning, Mixing, and Placing Concrete.

1. Proportion and mix concrete according to the applicable requirements of Article 2403.02, D, 3.

2. Do not place concrete when the ambient temperature is below 35°F unless the Engineer has approved the plant for cold weather concrete placement. When necessary, heat the aggregate or water, or both, so that the temperature of concrete when deposited in the forms is 40°F to 90°F. Do not use frozen material in concrete.

3. When a series of units is cast in a line, cast the entire series in one continuous operation, or as directed by the Engineer. Place successive batches before the preceding batch has perceptibly hardened or dried. Do not allow more than 45 minutes to pass between the placement of successive batches of concrete in a unit. Do not retemper the concrete or add water to the interface of the concrete between batches.

4. Carefully work and consolidate concrete around reinforcement without displacing it. Ensure the formation of honeycomb, stone pockets, or similar defects has not occured. Consolidate the concrete using small diameter vibrators or by other means the Engineer approves. Overfill the forms during consolidation. Screed off excess concrete and finish the surface to the desired texture.

5. On specific request and approval, provisions may be made for inserts in beams as an aid to stripping floor forms. Complete this according to the conditions of such approval.

D. Curing.

1. Use a method of curing that prevents loss of moisture and maintains an internal concrete temperature of at least 40°F and not more than 155°F during the curing period. Obtain the Engineer's approval for this method.

2. When using accelerated heat curing, do so under a suitable enclosure. Use equipment and procedures that will ensure uniform control and distribution of heat and prevent local overheating. Ensure the curing process is under the direct supervision and control of competent operators.

3. When accelerated heat is used to obtain temperatures above 100°F:
   a. Record the temperature of the interior of the concrete using a system capable of automatically producing a temperature record at intervals of no more than 15 minutes during the entire curing period.
   b. Space the systems at a minimum of one location per 100 feet of length per unit or fraction thereof, with a maximum of three locations along each line of units being cured.
   c. Ensure all units, when calibrated individually, are accurate within ± 5°F.

d. Do not artificially raise the temperature of the concrete above 100°F for a minimum of 2 hours after the units have been cast. After the 2 hour period, the temperature of the concrete may be raised to a maximum temperature of 155°F at a rate not to exceed 25°F per hour.
e. Hold the maximum temperature for a period sufficient to develop the strength required for release of prestress or for post tensioning, as the case may be.
f. Lower the temperature of the concrete at a rate not to exceed 40°F per hour by reducing the amount of heat applied until the interior of the concrete has reached the temperature of the surrounding air.

4. In all cases, cover the concrete and leave covered until curing is completed. Side forms and pans forming the underside of channel shapes may be removed during this period if the cover is immediately replaced. Do not, under any circumstances, remove units from the casting bed until the strength requirements are met.

5. For pretensioned beams, maintain the temperature of the beams and exposed strands at normal curing temperature until the stress has been released from the end anchorages.

E. Placing Reinforcement.

1. Place all reinforcement carefully and accurately and secure in the proper position according to the contract documents. Apply Article 2404.03.

2. Only welders qualified according to Article 2408.03, B, may perform welding if it is employed in placement of reinforcing steel, or the interconnection of plate connectors, sole plates, or masonry plates. Apply Article 2408.03, B, to the period of effectiveness for all welders. For tack welding reinforcing bars, follow all other requirements as outlined in the latest edition of AWS D1.4, including Table 5.2, Minimum Preheat and Interpass Temperature, except do not allow the minimum preheat and interpass temperature to drop below 50°F. Ensure the minimum preheat and interpass temperatures for structural steel remain as in Article 2408.03, B.

3. Protect prestressing tendons from heat and weld spatter. Tack welding of reinforcing steel at noncritical stress areas in combination with sacrificial reinforcing bars, if required, will be allowed without regard to preheat and interpass temperature restrictions. Obtain the Engineer's approval for any such modification.

F. Removal of Forms.
If forms are removed before the concrete has attained the strength which will permit the units to be moved or stressed, remove protection only from the immediate section from which forms are being removed. Immediately replace the protection and resume curing after the forms are removed. Do not remove protection any time before the units attain the specified compressive strength when the surrounding air temperature is below 20°F.

G. Prestressing Steel Stresses.

1. Position the number and size of individual tendons (7wire strand) according to the contract documents. Prestress to the force shown in the contract documents.

2. If anchored at other than 70°F, adjust the initial prestressing force as shown in Table 2407.03-2:

Table 2407.03-2: Initial Prestressing Force

Temperature of Strands	Initial Prestressing Force
70°F	As shown in the contract documents
Below 70°F	Increase 1.0% per 10°F
Above 70°F	Decrease 1.0% per 10°F

3. After tendons have been positioned, apply an initial force between 1000 and 4500 pounds to each tendon. Measure the initial force within a tolerance of:
   - ± 100 pounds for initial forces under 3000 pounds, and
   - ± 200 pounds for initial forces of 3000 pounds or more.

4. The theoretical elongation of the tendons is calculated from material properties furnished by the manufacturer and allowable losses. Allowable losses may include seating losses, bed shortening, abutment movement, and temperature adjustments.

5. Measure the pretensioning by the net elongation of the tendons. Consider the calculated theoretical net elongation to be the target. A tolerance of ±1/2 inch from the calculated net elongation, after seating, may be allowed.

6. Conduct the tensioning procedure so the indicated stress, measured by the tensioning system, is within 5% of the calculated stress, based upon the corresponding elongation. Verify the distribution of the stress is within 5% of the calculated stress at all points along the tendon or when measured at the end of the bed.

7. Temporary overstressing of the tendons is allowed; however, at no time exceed 80% of the specified tensile strength of the tendons. Do not seat tendons in this overstress condition.

8. Tension tendons between fixed end anchorages by means of jacks either separately or in a group. Several units may be cast in one continuous line. In this case tension them simultaneously.

9. Deflected tendons may be tensioned in place. Alternatively, deflected tendons may be partially tensioned and then raised to the predetermined final position at the beam ends, achieving the required prestressing force. Tendons may be raised simultaneously to the predetermined final position or at any one point, in a single lift, provided the sequence of lifting commences at the point nearest the center of the bed and then progresses alternately at points equidistant from the center to the ends.

10. Support tendons at each deflection point on a freely rotating metal pulley no less than 3/4 inch in diameter.

11. Limit the number of broken strand wires to no more than 2% of the total number of strand wires or no more than one broken wire of any one strand.

H. Prestress Transfer.

1. When accelerated heat curing is used, perform prestress transfer immediately after the curing period is completed and while the concrete is warm and moist.

2. Deflected tendons, if any, are to be released first either by:
   - Lowering holdup devices at beam ends as nearly simultaneously as practical, or if this is not feasible,
   - Flame cutting deflected tendons in each beam interval in rotation until all deflected tendons are released. Obtain the Engineer's approval for the procedure used to flame cut deflected tendons.

3. Next, release the hold down devices and simultaneously and gradually release the straight line tendons using the jack. If this is not feasible, heat the tendons as follows:
   a. For each tendon, simultaneously heat a minimum of two locations along the casting bed.
   b. Apply heat along the tendon over a minimum 5 inch distance.
   c. Control heat application so that failure of the first wire in the tendon does not occur for at least 5 seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. Heat the tendon until failure occurs at each beam interval before proceeding to the next tendon.
   d. Sequence prestress transfer between individual tendons so that there is minimum eccentricity of prestress load.
   e. Alternate procedures for releasing deflected or straight line tendons may be submitted for the Engineer's approval.

4. Measure the initial camber due to prestress according to Materials I.M. 570.

I. Post Tensioned Prestressed Concrete.
When post tensioned construction is designated, detailed procedures will be included in the contract documents.

J. Tolerances.
Apply the following tolerances for precast and prestressed units:

1. **Precast Nonprestressed Bridge Units.**
   a. Limit variation from dimensions shown in the contract documents to no more than 1/8 inch. For overruns, greater deviation may be accepted if, in the Engineer's opinion, it does not impair the suitability of the member for its intended use.
   b. Ensure beam seat bearing areas at each end of the unit are flat and true and perpendicular transversely to the vertical axis of the beam.
   c. Limit the difference of cambers between two adjacent units, as assembled, to no more than 1/8 inch.

2. **Precast Prestressed Bridge Units.**
   Limit variation from dimensions shown in the contract documents to the tolerances shown in Table 2407.03-3:

Table 2407.03-3: Tolerances

Length	±1/4" per 25' and ±1" max. for beams 100' or longer
Width (flanges and fillets)	+3/8" or -1/4"
Depth (overall)	+1/2" or -1/4"
Width (web)	+3/8" or -1/4"
Depth (flanges and fillets)	±1/4"

Bearing plates (ctr. to ctr.)	1/8” per 10’ of beam length, max. ±3/4”
Sweep (deviations from straight line parallel to center line of member)	L/80 (L in feet, sweep is in inches)
Camber deviation from design camber	±30% of plan camber
Stirrup bars (project above top of beam)	+1/4” or -3/4”
Individual tendon position	
Straight strands	±1/4”
Draped strands at end of beam	±1/2”
Tendon position	
Center of gravity of strand group	±1/4”
Center of gravity of depressed strand group at end of beam	±1”
Deviation from net theoretical elongation after final seating	± 1/2”
Position of deflection points for deflected strands	5% of beam span toward end of beam
Position of handling devices	±6”
Bearing plates (ctr. to end of beam)	±3/8”
Side inserts (ctr. to ctr and ctr. to end)	±1/2”
Exposed beam ends (deviation from square or designated skew)	
Horizontal	±1/4”
Vertical	±1/8” per foot of beam depth
Bearing area deviation from plane	±1/16”
Stirrup bars (longitudinal spacing)	±1”
Position of post tensioning duct	±1/4”
Position of weld plates	±1”
Elongation (standard gauge length to be a minimum of 20 feet (6 m))	±5%

K. Handling and Storage.

1. When lifting and handling precast or prestressed units, support them at or near the points designated in the contract documents. Do not allow the overhang to exceed 5% of the length of the beam, unless specified otherwise in the contract documents.

2. Do not lift or strain units in any way before they have developed the strength specified. In storage, support units at points adjacent to the bearings.

3. Support piles near the one-fifth points measured from the ends. In stacking units for storage, arrange the bearings one directly above another.

4. Legibly mark piles with the casting date in fresh concrete near the head of the pile, using numerals only.

5. During fabrication, storage, handling, and hauling take care to prevent cracking, twisting, unnecessary roughness, or other damage. In particular, do not allow tiedowns to come in direct contact with concrete surfaces. Do not subject units to excessive impact. Replace at no additional cost to the Contracting Authority units that are, in the Engineer’s opinion, damaged in a way to impair their strength or suitability for their intended use.

L. Finish.

1. Finish all surfaces which will be exposed in the finished structure as provided in Article 2403.03, P, 2, b, and ensure they are free of honeycomb or surface defects. Submit Structural Repair procedures to the Engineer for approval.

2. Finish the outer surface of exterior beams as follows:
a. As soon as practical after removal of the forms, remove all fins and other surface projections.
b. Brush or spray a prepared grout onto the prewetted surface. Use a grout consisting of one part of silica sand and one part of Portland cement blended with acrylic bonding agent and water to produce a consistency sufficient to

fill the cavities. The Engineer may require white Portland cement to be used in amounts necessary to obtain a uniform finish.
   - **c.** Immediately after applying the grout, float finish the surface with a cork or other suitable float. Ensure this operation completely fills all holes and depressions on the surface.
   - **d.** When the grout is of such plasticity that it will not be pulled from holes or depressions, use a sponge rubber float to remove all excess grout.
   - **e.** When the surface is thoroughly dry, rub it vigorously with dry burlap to completely remove excess dried grout.
   - **f.** Cure the surface finish in a manner satisfactory to the Engineer. Heat curing may be required in cold weather.
   - **g.** Ensure, when finished, the surface is free from stains and has a uniform color.

3. Cut and bend tendon projections as detailed in the contract documents. Cut the tendon off flush with the concrete where the tendon end will be exposed in the complete structure. Clean the end of each cut off tendon to a bright appearance.

4. Coat and seal beam ends exposed in the complete structure with an approved gray or clear epoxy listed in Materials I.M. 491.19, Appendix B. Coat and seal beam ends as indicated on the plans. Apply the epoxy coating and beam end sealing at the fabricating plant.

2407.04 METHOD OF MEASUREMENT.

A. For precast or prestressed structural units, the Engineer will determine the number of units of each of the various respective sizes, lengths, and types from actual count. Measurement of precast sheet piles or precast or prestressed bearing piles will be according to Article 2501.04.

B. For cast-in-place prestressed concrete, measurement for concrete, reinforcing steel, and structural steel will be according to Article 2403.04 for structural concrete, and the prestressing will be a lump sum item.

2407.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for the number of approved precast or prestressed structural units of each size and length incorporated in the project.

B. Payment is full compensation for:
- Producing and furnishing the units complete as shown in the contract documents, with all plates, pads, bolts, grout enclosures, reinforcing steel, prestressing material, coil rods, hold down devices, and any other items to be cast in the concrete,
- Transporting units to the site and placing them in the structure,
- Furnishing and installing bearing plates and anchor bolts or neoprene pads when specified in the contract documents.

C. Payment for furnishing precast sheet piles or precast or prestressed bearing piles will be as provided in Article 2501.05.

D. Payment for cast-in-place prestressed concrete will be according to Article 2403.05. The prestressing will be paid for as a lump sum item. The lump sum amount is full payment for furnishing and placing the required material and stressing, anchoring, and grouting the prestressing steel according to the contract documents.

PRECAST & PRESTRESSED CONCRETE BRIDGE UNITS

GENERAL

The purpose of this Instructional Memorandum is to set forth the minimum requirements of the fabricator's Quality Control Program for the fabrication and inspection of precast/prestressed concrete bridge units. Approved producers and fabricators are listed in the Materials Approved Products Listing Enterprise (MAPLE). Apply this IM to both LRFD and LX beams except otherwise noted.

SCOPE

To ensure that all work performed will be in accordance with the contract documents by establishing management commitment to quality control, with trained, qualified, certified personnel and uniform production procedures.

FABRICATOR APPROVAL

In order to furnish precast/prestressed bridge units to projects administered by the Iowa Department of Transportation, the fabricator shall be placed on the approved producer/fabricator list (Appendix A) prior to the letting.

Each fabricator must submit a written application to the respective District Materials Engineer (DME). This application shall detail the fabricator's Quality Control Program. NOTE: Fabricators with operations in more than one District shall apply to the appropriate DME for each site. (A sample application is attached to this IM.)

Prestressed concrete plant approval shall be dependent on a satisfactory inspection of the plant by both District Materials Engineer and the Prestressed and Precast Concrete Engineer after the plant's quality control plan meets all the Iowa DOT requirements and recommendation by the District Materials Engineer (DME) responsible for inspection of the plant.

Each fabricator/producer shall have a plant specific Quality Control Procedure Manual modeled and detailed in accordance with the "Guidelines" for the fabrication of precast/prestressed bridge units intended for use on state, county and/or city projects. Guidelines of quality control for the fabrication of precast/prestressed bridge units are listed in Appendix F of this IM.

These guidelines are considered the principal factors in quality control and are the basis upon which each plant-specific procedure manual will be accepted and/or rejected. The plant-specific procedure manual shall detail fabrication procedures such as but not limited to: description of production lines, calculation procedure, tensioning procedures, concrete mixtures, approved mix designs, concrete placement and consolidation, detentioning procedures, curing procedures, repair and finishing procedures, handling, storage and shipping procedures. A sample of the forms used by the fabricator to document plant quality control inspection shall be approved by the DME and be included in the manual. A copy of this manual shall be submitted to the Iowa Department of Transportation for approval by the DME and the Prestressed & Precast Concrete Engineer.

The fabricator shall have a sufficient number of qualified, certified, capable personnel to perform the necessary quality control functions. This includes, but is not limited to, activities such as ensuring proper placement of steel reinforcement, placement and tensioning of strand, material identification and handling, concrete proportioning, mixing and consolidation, fabrication, marking, curing, and documentation. The quality control personnel shall be responsible for all phases of fabrication, for units being produced for state, county, and/or city projects.

Safety: To assure safety, the fabricator shall have a safety policy, safety program, safety manual and a designated safety officer responsible for enforcing the safety rules. Additionally, each fabricator shall comply with all applicable laws, rules, regulations, and ordinances governing safety. The fabricator shall make adequate provisions satisfactory to the DME for the safety of the inspector, particularly at all sampling, tensioning, and inspection locations. Any violation of the Safety Laws, Rules or Regulations may be considered sufficient grounds by the DME for suspending all inspection activities.

QUALITY CONTROL PROGRAM

The fabricator's written application shall detail the following:

1. A flowchart listing the chain-of-command to aid in problem solving and to facilitate communication between the Iowa DOT inspector and appropriate fabricator personnel. Included in the flowchart shall be a statement of management commitment to, and responsibility for, maintaining the Quality Control Program.

    a. Quality control inspections shall be performed by QC and/or by personnel other than those responsible for production and thus, reporting directly to management.

    b. Deviations from the established flowchart, in personnel that will affect the Quality Control Program, require prior approval from the DME (i.e., situations involving the temporary absence of personnel normally responsible for quality control inspection).

2. A statement that the fabricator will maintain qualified (certified) personnel.

3. Designation of how specification requirements are relayed to the responsible quality control personnel and which company representative is responsible for this task.

4. A statement that the approved plant-specific procedural manual will be adhered to maintained and updated as needed.

REMOVAL FROM THE APPROVED LIST

Significant and/or repeated non-compliance with the DOT contract documents will warrant a corrective action request (CAR) being submitted to the fabricator. The fabricator will have 20 working days to submit a corrective action plan for approval. Production may continue during this 20 day period with DOT inspection. If the corrective action plan is not approved, the fabricator will be in conditional status for 30 working days. During conditional status the fabricator shall hire an Iowa DOT approved consultant to inspect the fabrication. The DOT Materials Fabrication Inspector will oversee the fabricator and consultant. Products fabricated during this time will be approved for use based on acceptable consultant reports in conjunction with DOT review. Continued non-compliance will be considered grounds to remove the fabricator from the approved list. The ongoing project will be completed with consultant inspection and DOT review. Conditional status will be withdrawn with a satisfactory report from the consultant and Iowa DOT Fabrication Inspector at any time during the 30 day period.

Willful misrepresentation by the fabricator, intentional shipment of non-approved products or repeated placement on conditional status (three times in three years) will be considered grounds for removal from the approved list.

Any fabricator removed from the approved list may be considered for reinstatement by reapplying after the items of concern have been addressed.

An appeal may be made to the Review Board if the fabricator wishes to contest the conditional status. The Review Board will meet as needed for disciplinary actions and appeals involving approved producers.

Iowa DOT inspection of fabrication will be suspended until the conditional status is rescinded by the Review Board.

The Review Board will consist of the Iowa DOT Construction and Materials Engineer, the Iowa DOT Prestressed & Precast Concrete Engineer, and the Chief Structural Design Engineer.

Each Precast/Prestressed plant shall submit the updated quality control plan to District Materials Engineer at the end of every other calendar year. Precast/Prestressed plants without updated quality control plan at January 31st will be delisted from the approve list.

Any fabricator removed from the list may be considered for reinstatement by reapplying to the appropriate DME and the Review Board.

CERTIFIED PRECAST/PRESTRESSED PERSONNEL

The Iowa DOT Office of Materials shall certify inspectors and Quality Control Technicians responsible for the inspection of precast/prestressed concrete bridge units.

Certification requirements are as follows:

1. Successful completion of the Iowa DOT training course (a score of at least 80% on the written test).

2. Experience of forty hours (of a variety of prestress work) assisting in quality control inspection at an approved plant. **NOTE:** The required forty hours must be documented and approved by the DME. A sample of Prestress Work History (40 hours) Form is attached to this IM.

Certification will be valid for a five-year period, after which the technician will retest to maintain certification.

The Quality Control Technician will be appointed by the producer and will be responsible for the quality control process and testing at each plant. The Quality Control Technician will have the following:

1. Knowledge of the plans, shop drawings and specification requirements.

2. Knowledge of the product manufacturing operations.

3. A valid DOT Level I PCC Certification or ACI Level I Certification.

If technicians perform aggregate gradation, they shall possess an Aggregate Level II Certification.

CERTIFICATION

Upon successfully completing the requirements for certification, the Program Director will issue a certificate and a pocket certification card. This certification is not transferable.

PERFORMANCE REQUIREMENTS

A written notice may be issued to the certified technician for any inadequacies performed during their duties. Upon receipt of two such notices, the certified technician may be given a three-month suspension. After three written notices, the certified technician is subject to decertification.

DECERTIFICATION

The certificate will become invalid for reasons such as:

1. Failure of the certificate holder to renew the certificate prior to regular expiration described above.

2. False or fraudulent use of information to secure or renew the certificate.

3. False or fraudulent actions or documentation by the certificate holder.

4. Not performing tests and technician's duties properly and in accordance to specification.

RENEWAL OF CERTIFICATION

Certifications will remain valid for five years (a three-month grace period will be allowed). If the individual has not renewed their certification within the 90-day grace period, she/he will be automatically decertified. The individual may obtain certification by taking the examination. If the individual does not take the examination within one year from the date of decertification, he/she must retake all applicable schools and pass the examinations. **The responsibility for applying for recertification shall rest with the certified individual.**

It shall be the responsibility of the individual to inform the Office of Construction and Materials of any address change.

Retesting will be required every five years regardless of work experience or performance. Failure of any certification test shall require the applicant to retake the applicable school and pass the test.

Detailed information on certification, decertification, and recertification is located in IM 213.

PREFABRICATION MEETING

The fabricator shall initiate this meeting prior to the commencement of any fabrication. Representatives of both the fabricating plant and the DOT shall attend this meeting.

Items to be discussed are:

- Production schedule

- Applicable specifications, IMs, shop drawings, and design standards
- Approved mix designs
- Methods of testing and curing
- Materials testing, acceptance, and approval
- Material storage and handling
- Quality Control Program and certification requirements
- Fabrication errors, discrepancies, and repair methods
- Acceptance and approval of final products
- Cylinder strength requirements
- Initial camber reading
- Final inspection
- Shipping procedure and protection
- Documentation of the prefabrication meeting
- District Materials Engineer must be notified before combined pours with altered strand design patterns or with multiple size differentials.
- By mutual agreement, periodic scheduled meetings between the fabricator and the District Materials Engineer may be used in lieu of the prefabrication meeting.

MATERIAL APPROVAL, CERTIFICATIONS & SAMPLING FREQUENCY

All materials for use in precast/prestressed concrete fabrication shall meet the requirements of the Standard Specifications and the IMs.

- **Cement** - Cement shall be from an approved source (listed in IM 401, Appendix A) and shall meet the requirements of Section 4101 of the Standard Specifications. Monitor samples shall be at the rate of one sample per year per supplier.

- **Fly Ash** - Fly Ash shall be from an approved source (listed in IM 491.17, Appendix A) and shall meet the requirements of Section 4108 of the Standard Specifications. Monitor samples shall be at the rate of one sample per ~~month~~ year per supplier.

- **Ground Granulated Blast Furnace Slag (GGBFS)** - Ground Granulated Blast Furnace Slag shall be from an approved source (listed in IM 491.14, Appendix A) and shall meet the requirements of Section 4108 of the Standard Specifications. Monitor samples shall be at the rate of one sample per ~~month~~ year per supplier.

- **Concrete –** Same mix shall be used on all beams in an individual span (camber issue) and in all exterior beams (color issue)
  - Self consolidating concrete, if used shall meet the requirements of IM 445 Appendix D.

- **Fine Aggregate** - Fine Aggregate shall be from an approved source and shall meet the requirements of Section 4110 of the Standard Specifications. The fabricator shall perform certified gradation testing at a minimum frequency of one test per week per source during production of certified project items. If the fabricator is using aggregate producer gradations, use "Producer Quality Control Testing Frequency" shown in Table 1 of Materials IM 209

- **Coarse Aggregate** - Coarse Aggregate shall meet the requirements of Section 4115 of the Standard Specifications, and shall be Class III durability aggregate. The fabricator shall perform certified gradation testing at a minimum frequency of one test per week per source during production of certified project items. If the fabricator is using aggregate producer gradations, use “Producer Quality Control Testing Frequency” shown in Table 1 of Materials IM 209.

- **Admixtures** - Admixtures shall be from an approved source and shall meet the requirements of Section 4103 of the Standard Specifications.

- **Steel and Iron Products** – All reinforcing steel, iron products, and coatings shall meet the requirements of IM 107.

- **Strand for Prestressing** - Strand for prestressing shall be from a domestic source and shall be the size, grade, and type specified in the contract documents. The fabricator shall provide certified Mill Test Reports and load-elongation curves. Prestressed strand may be accepted by certification, and monitored by sampling and testing at the rate of one sample per heat. Sample size is 6 ft. length of strand with copies of certified Mill Test Reports. All strands shall be free of contamination (dirt, mud, oil, paint, wax, etc.) that may prevent bonding between the strands and the concrete. Strands shall be free from nicks, kinks, and excessive rust. Rusting is generally acceptable if the rust is light and if pitting is not evident. Strand shall conform to the requirements of AASHTO M203 M (ASTM A416, Grade 270, ASTM A416M, Grade 1860), seven-wire prestressing strand. Strand suppliers shall provide the following certification:

  > "The materials itemized in this shipment are certified to be in compliance with the applicable AASHTO and/or ASTM requirements and Iowa Department of Transportation Standard Plans and Specifications, IMs and meet the Buy America requirements as described in IM 107 for all steel, iron products and coatings."

  ____
  Authorized Signature and Date

  Audit results from the National Transportation Product Evaluation Program (NTPEP) are required for plant approval. Upon satisfactory review the manufacturing mill will be placed on the approved list in Appendix C of this IM.

- **Wire Failure-Prestressing Strands**-During stressing of seven-wire prestressing strands for a single beam or one line of beams cast with a common strands, the number of individual wire failure shall not exceed 2% of the total number of wires. The permissible number of wire failure shall be rounded to the next lowest whole number. No individual strand shall have more than one wire failure.

  Example - D 100, No. of 7-wire strands = 28, total number of wires = 196, 2% of total number of wires = 3.92, max allowable No. of strands with one wire failure = 3.

- **Uncoated Reinforcement** - Steel reinforcement for precasting/prestressing shall be grade 60 (ASTM A615) and shall be from an approved source and shall be accompanied by a Mill Test Certification and shall comply with the requirements of Section 4151.03 of the Standard Specifications. Monitor sampling will be done at a minimum rate of one sample of the most common bar per manufacturer per year. Rusting is generally acceptable if the rust is light and if pitting is not evident.

- **Epoxy-Coated Steel Reinforcement** for precasting/prestressing shall meet the requirements of ASTM A615, Grade 60, IM 451.03B, Article 4151.03B of the Standard Specifications and the following requirements:

    1. Epoxy coated steel shall be from an approved source and an approved coater.

    2. Epoxy coated steel shall be accompanied by a Mill Test Certification and Certified Coating Report.

    3. Assurance verification, sampling and testing shall be performed at the fabrication plant by the Iowa DOT QA Inspector. Frequency of sampling and testing shall be a project-by-project basis and shall include and not be limited to the following:

        a. Measurement of epoxy coating thickness (acceptance)

        b. Visual observation of the coated bars and stirrups for uniform coating and cracking (verification)

        c. The QA Inspector shall submit one sample of coated bar and stirrup for testing by Central Laboratory at a frequency of one sample per size, per year, per manufacturer (coater).

    4. Epoxy coated steel shall be properly identified.

    5. Epoxy coated steel shall remain bundled and tagged until immediately before it is to be incorporated into the beam or the precast items. **NOTE:** Leftovers or remnants of epoxy steel shall be properly identified, stored, protected and traced to original Mill Test Report or an invoice or to a bill of lading in order to be accepted.

    6. Epoxy coated reinforcement should be protected from sunlight and weather exposure and long-term storage should be avoided.

- **Alternative Top Transverse Bar Placement for Bulb Tee Beams –** The six 5a bars in the top of the beam as shown in the beam detail sheets may be replaced by four 0.6-in diameter strands. The strands shall be located 2" from the top of the beams to the centers of the strands. Spacing of the strands across the width of the top flange shall be as shown on the beam standards. The 4c1 bars shall be placed on top of the strands.

- **Sole Plates, Steel & Masonry Curved Sole Plates** - Acceptance shall be on the basis of approved shop drawings, acceptable workmanship, and fabrication inspection reports which shall include mill certification, type and steel grade, and galvanizing checks. ASTM A852, Grade 70 is required. ASTM A514, Grade B or ASTM A709, Grade 70W structural steel may be substituted for ASTM A852, Grade 70. The producers are required to submit the shop drawings to the Bridges and Structures Bureau. For BT beams as long as the fabricator of the curved sole plates remain same, the beam producers can use the same approval for all the projects.

- **Protection Plates** - Acceptance shall be on the basis of approved shop drawings, and acceptable workmanship. Protection plates can be used at the discretion of the producer/fabricator. Protection Plates shall be made of ASTM A36 and shall be fully galvanized in accordance with the requirements of ASTM A121 (See Appendix H & H1 for details).

- **Inserts/Hangers** – Acceptance shall be on the basis of approved shop drawings, which shall include the manufacturer's design, spacing and installation requirements. Inserts/hangers can be used in prestressed beams (1) upon request by the contractor as an aid to stripping floor forms, (2) shall be coated using one of the following methods:

    1. Electroplating in accordance with ASTM B633, service condition SC4, required coating thickness of 1.0 mil. Classification and coating suffix FE / Zn 25
    2. Mechanical galvanizing in accordance with ASTM B695, Type 1, Class 50. Minimum coating thickness shall be 2 mils.

- **Neoprene Bearing Pads** - Neoprene bearing pads will be accepted from an approved manufacturer on the basis of certification with monitor sampling and testing in accordance with IM 495.03 and Article 4195.02 of the Standard Specifications.

- **Coil Ties and Hold Downs** - Will be accepted per the manufacturer's certification once per year per size.

- **Water** - Water shall meet the requirements of Article 4102.01 and will be sampled once per year.

- A copy of reports of approved materials, cement certifications, Mill Test Reports for steel reinforcement, etc., shall be kept on file by the fabricator and be available for examination by the engineer for one calendar year after the prestressed units are incorporated into a project.

EQUIPMENT & PLANT APPROVAL

- An independent registered professional engineer shall design casting beds and approve the equipment. The design shall be stamped, approved and signed by the registered professional engineer who designed the casting beds. Annual safety inspection to verify the adequacy of the bed(s) (vertical movement) shall be performed and documented by the producer. A copy of the safety inspection shall be submitted to the State of Iowa upon request. Calculation shall be submitted to the Iowa Department of Transportation should there be any anticipated change(s) in the maximum intended loading.

- Plan dimensions and specification values are to be considered as the target value to strive for and comply with as the design value from which deviations (within tolerances) are allowed. If any plan or specification changes are implemented, then the revised values shall govern.

- Casting beds, forms and bulkheads shall meet the requirements of Article 2407.03 of the Standard Specifications. Casting beds shall be checked for line and grade at a frequency of at least once per year or as often as necessary. This check shall be performed and documented by the fabricator. Casting beds, forms, and bulkheads that are not mortar tight shall be sealed or repaired prior to reuse.

- Forms shall be straight and true to the line. Form joints shall be comparable and even with each other.

- Weighing and proportioning equipment shall meet the requirements of Article 2001.20 of the Standard Specifications except that a vibrator will not be required on the cement batch hopper. Batching and proportioning equipment and scales shall be calibrated at least once a year. The Engineer may order a verification calibration test or check as necessary to ensure continued compliance.

- Mixing equipment shall meet the requirements of Article 2001.21 of the Standard Specifications.

- Stressing equipment shall be in accordance with Article 2407.03.A.3 of the Standard Specifications and shall be calibrated at a frequency of at least once per year or when is determined necessary. Calibration of the jacking system shall compare the indicated force applied by the system, to the force indicated on a calibrated load cell, dynamometer, or proving ring.

- When artificial heat is used to obtain temperatures above 100°F the temperature of the interior of the concrete shall be recorded by a system meeting the requirements of Article 2407.03.D of the Standard Specifications.

- Keep the maximum curing temperature of the concrete to 155°F. During curing record the temperature of the interior of the concrete using a system meeting the requirements of Article 2407.03.D of the Standard Specifications when the concrete temperature is above 100°F.

- Concrete temperature shall be uniform throughout the curing process and shall not vary by more than 40°F through the entire casting bed. Temperature probe locations shall be randomly located within 100 ft. throughout the length of the line (each line).

- Concrete shall not be placed without the written permission of the engineer when:

  a. Ambient temperature is below 35°F Article 2407.03.C)

  b. Plant approval by the engineer is required for cold weather placement.

- Automatic moisture measuring-equipment for aggregate shall comply with the requirements of IM 527.

- Testing equipment shall have sufficient capacity for the testing involved. Cylinder breaking equipment shall be calibrated at a minimum frequency of once per year.

- Jack calibration/tensioning equipment calibration shall be performed by an independent certified, approved laboratory and witnessed by Iowa DOT.

- Plant calibration shall be performed once a year and/or as needed by an independent certified, approved laboratory and witnessed by Iowa DOT.

DOT INSPECTOR KNOWLEDGE & DUTIES

The inspector's main functions are to monitor production, report findings and assist in quality improvement wherever possible. This is done to ensure that the Quality Control Program provided by the fabricator is functioning and is adequate to produce acceptable products.

The inspector is the liaison between the contracting authority and the fabricator. Good communications are important to maintain a good working relationship between the inspector and fabricator.

The inspector should be familiar with Standard Specification Article 1105.06, which describes the authority and duties of the inspector. He/she will not direct the fabricator's activities, but will have the authority and responsibility to question and, where necessary, reject any operation not in accordance with contract documents.

There are many phases included in the process of fabricating precast prestressed concrete products. While all phases are important to the overall quality of the product, there are several that the Agency inspector should make every effort to personally witness or perform:

- Verify tensioning calculations and tensioning production records as soon as possible after tensioning.
- Visually inspecting the product as soon as possible after casting.
- Approve repairs.
- Provide final inspection after repair and finish work is completed including excessive lateral sweep.
- Review fabricator’s documentation and prepare fabrication report.

An Iowa DOT inspector shall monitor the remaining phases as needed (as deemed necessary by the District Materials Engineer).

- Location of hold-ups and hold-downs, strand pattern, bed condition
- Placement of end plates, trueness of forms, insert type and location
- Tensioning operations
- Steel reinforcement and placement
- Concrete placement, making strength specimens, concrete operations
- Curing operation
- Compressive strength determination
- Detensioning operations
- Camber at release
- Finishing and repair operations
- Storage of units
- Loading and transporting (Overhang requirements; padding required if chains used for tie-downs.)

MINIMUM QUALITY CONTROL DUTIES BY THE FABRICATOR

The Quality Control Technician shall check and document the following:

PRE-POUR

- Identify and document materials requiring outside fabrication inspection.
- Identify potential fabrication or production problems and notify Iowa DOT inspectors.
- Verify that all materials incorporated meet the requirements of the contract documents.
- Review concrete placement documents for strand locations.
- Check tension calculations.
- Measure elongation and gauge pressure during tensioning.
- Check hold-down and insert locations.
- Check stress distributions.
- Check steel placement.
- Check strand position.
- Check condition of pallet (level, holes, gaps, and other deformities).
- Determine moisture of aggregates.
- Check form condition and placement (oil, line alignment level, and tightness)

CONCRETE PLACEMENT

- Check on use of an approved mix design and batching operations (sequence).
- Ensure appropriate placement and proper vibration techniques.
- Measure and record concrete temperature.
- Ensure test cylinders are properly made.
- Ensure test cylinders are properly cured.
- Ensure appropriate finish.
- Ensure appropriate curing operations.

POST-POUR

- Check temperature and record during curing process.
- Ensure concrete strength has been met prior to releasing the line.
- Ensure proper detensioning procedure.
- Check unit for defects and obtain approval for repairs.
- Identify and store cylinders with the respective units.
- Check beam ends for fabrication in accordance with the plans.
- Ensure exterior sides of facia beams are grouted.
- Measure and record overall dimensions of beam.
- Measure and record camber at release and compare to design camber. (See camber measurement procedures.)
- Check and/or measure and record lateral sweep before shipping. (See sweep measurement procedures.)
- Ensure proper cylinder cure. (Cylinders must remain moist throughout the entire cure process and until testing.)

CONCRETE STRENGTH

1. For release strength, see the requirements of Article 2407.03 of the Standard Specifications, and contract documents and/or as indicated on the plans.

2. For 28-day strength, see the requirements of Article 2407.03 of the Standard Specifications and/or as indicated on the plans. Prestress units cannot be shipped until the unit is minimum 14 days old. Prestressed piles may be shipped when the piles are 7 days old and attain 28-day strength.

3. Prestress units cannot be shipped until the 28-day strength is attained.

4. Beams must be at least 28 days old before the floor is placed, unless a shorter curing time is pre-approved by the engineer.

5. For each release and shipping strength a set of three (3) cylinders representing three different portions of the line cast (each end and the center) shall be cast. The average of three (3) cylinders shall be used to determine the minimum strength requirements for either release or shipping.

   For either release or shipping strengths the set of cylinders tested shall meet the following requirements:

   a. The average strength of the specimens tested shall be equal to or greater than the minimum strength required.

   b. No individual cylinder of the set tested shall have a compressive strength less than 95% of the specified strength.

   c. If both conditions a. & b. are not met after the appropriate curing period, another set of specimens representing the line shall be tested.

6. Concrete strength specimens shall maintain the same temperature as the cast unit until stripping strength is achieved. Strength specimens can be stored: with the cast unit, in an environment that duplicates the conditions of the cast unit, or in a method agreed upon by the Engineer.

DEBONDED PRESTRESSING STRANDS

When detailed in the bridge plans, sheathing of prestressing strands to provide debonding shall meet the following requirements:

1. Use slit sheathing with high density polyethylene or polypropylene plastic.
2. The sheathing must have a minimum wall thickness of 0.025 inch, and an inside diameter exceeding the maximum outside diameter of the prestressing strand by 0.025 inch to 0.140 inch.
3. Extend the tubular debonding material (sheathing) through the header for all debonded prestressing strands.
4. After strands have been stressed, tie and tape the debonding material at the terminus located at the inside of the member. The tape must be strong enough to hold the sheathing closed.
5. The sheathing and tape must not react with the concrete, coating, or steel.

6. Additional slit tubular sheathing may be used to repair minor defects such as breakages or punctures in the installed sheathing, rectifying an improperly debonded strand, or incorrect debonded length of a strand.
7. The slit sheathing must maintain its integrity during the placement of fresh concrete without opening the seam. Tape and tie to ensure mortar tightness of the sheathing tube.
8. Do not tie reinforcing bars to debonded prestressing strands within the limits of the sheathing material.
9. All costs for material and labor for furnishing and installing the debonding material shall be included in the cost for the prestressed beam bid item.

Releasing of beams with debonded strands shall be as follows:

1. If strands are not released as a unit, the following release sequence shall be used.
    a. Release draped strands and hold downs per IDOT Standard Specification 2407.03.H
    b. Release bonded strands.
    c. Debonded strands shall be released last with the shortest debonded strands released first and the longest debonded strands to be released last.
2. Any beam cracking noted during release shall be reported to the engineer for evaluation.
3. To measure the extent of debonding, strands shall be marked at a known distance from the end of the beam to measure the amount of retraction after cutting. Other methods to determine the extent of debonding may be considered with the approval of the Engineer.
4. All debonded strands shall be cutoff flush with the beam ends and shall not be embedded into the pier or abutment diaphragm concrete.
5. Seal openings between debonded strands and sheathing with 100% silicone sealant within fourteen calendar days of detensioning, before coating of the beam ends per I.M. 491.19 (if required in the bridge plans) and cure per the manufacturer's recommendations.

When detailed in the bridge plans, sheathing of prestressing strands to provide debonding shall meet the following requirements:

1. Use slit sheathing with high density polyethylene or polypropylene plastic.
2. The sheathing must have a minimum wall thickness of 0.025 inch, and an inside diameter exceeding the maximum outside diameter of the prestressing strand by 0.025 inch to 0.140 inch.
3. Extend the tubular debonding material (sheathing) through the header for all debonded prestressing strands.
4. After strands have been stressed, tie and tape the debonding material at the terminus located at the inside of the member. The tape must be strong enough to hold the sheathing closed.
5. The sheathing and tape must not react with the concrete, coating, or steel.
6. Additional slit tubular sheathing may be used to repair minor defects such as breakages or punctures in the installed sheathing, rectifying an improperly debonded strand, or incorrect debonded length of a strand.
7. The slit sheathing must maintain its integrity during the placement of fresh concrete without opening the seam. Tape and tie to ensure mortar tightness of the sheathing tube.
8. Do not tie reinforcing bars to debonded prestressing strands within the limits of the sheathing material.
9. All costs for material and labor for furnishing and installing the debonding material shall be included in the cost for the prestressed beam bid item.

REPAIR, FINISH, HANDLING & STORAGE

Prestressed/Precast units shall be free from honeycomb, surface defects, surface voids, bug holes and oil stain. Bug holes can be accepted if they are less than 1/2" in diameter (as measured by a DOT template) and not in a concentrated form (shot gun appearance).

Honeycomb and surface defects (exterior and interior beams) shall be filled and finished in accordance with the requirements of Article 2407.03.L of the Specifications. Bug Holes smaller than 1/2 in. in diameter need not to be filled unless it's in a concentrated form. NOTE: For definition of honeycomb, bug holes and surface defects please refer to Appendix G of this IM.

Handling and storage shall be done in accordance with the requirements of Article 2407.03K of the Standard Specifications.

The Prestressed units shall be fabricated as per the plans and the bridge standards. No alterations or coring of the Prestressed units are allowed without the approval of the Precast and Prestressed Engineer or the Bridge Engineer.

The top of each beam will have a tined finish (grooves), except for a smooth strip, approximately two inches wide, continuously along one side of the beam. Grooves will be 1/4 inch in depth, spaced at not more than one inch center to center and will have a width of 1/8-inch ± 1/16-inch.

The outer surface of "Exterior Girders" shall have a surface finish in accordance with the requirement of Article 2407.03.L of the Standard Specifications. The finished surfaces shall be free of surface defects, oil stain and shall have a uniform color.

When required by the plans, beam-ends shall be coated and sealed at the prestressed fabrication plant with an approved gray or clear epoxy listed in MAPLE (IM 491.19, Appendix B).

The overhang shall not exceed 5 percent of the length of the beam and/or as indicated in the contract documents.

IDENTIFICATION

Each unit must have legible identification. Identification must remain in place and legible until the final project is accepted by Owner. Pieces with fading identification must be re-marked before any of the information becomes illegible.

Identification must include all of the following marked on the web approximately mid span between the beam end and the first diaphragm location:

a. Producer's Name and Plant Location
b. Unique Beam Number (schema designed so no two beams from any plant can ever have the same number)
c. Fabrication Date MM-DD-YYYY

Identification must include the word "EXTERIOR" clearly visible at each end of the exterior face of the facia girder.

Identification must include the acceptance mark of the QA inspector prior to shipping. Prestressed/precast units that are not marked as accepted by the QA Inspector shall be rejected at the project site and cannot be incorporated into the project.

CAMBER MEASUREMENT PROCEDURE

Initial camber due to prestress shall be measured after lifting and resetting the beam within three hours after detensioning and separation of the beam. After lifting, the beam may be reset on the precasting bed or in a holding area or storage yard. The beams with initial camber within 30% of designed release camber are considered as compliant camber. The compliance will be expired at the end of 120 days from the casting date of the beam. The 120 days is the time for the full designed camber, consisting of the initial camber and after losses camber, to develop. The theoretical 120 days of age is based upon the support of the PPC beam in storage being at L/30 after initial camber measurement. Beam support locations during storage will not be directly addressed at this time however it does have an effect on beam camber growth.

Camber of the beams shall be verified after delivery to the project. Beams cannot be accepted without specific approval of the project engineer after delivery to the project.

Initial Camber Measurement Procedure:

Fabricators shall use the survey equipment such as levelling instrument or equivalent to take elevation readings at the beam ends and beam midpoint to the nearest hundredth of a foot (0.01 feet). Survey shots are based on the top of the beam top flange and the fabricators are required to produce a flat surface across the full width of the top flange at the center line of the bearing locations and at midspan. The following steps shall be taken to ensure correct camber measurement.

1) Cast concrete and screed top surface.
2) Provide a level and smooth surface in the plastic concrete of the beam top at midspan and at the center line of bearing locations from which to measure camber. Surfaces shall span the entire width of the beam, measure at least 3.5 inches long centered at the required locations, and be flush with the top of the form edges. These surfaces may be troweled into the beam top, formed into the top by clamping a rigid material to the forms spanning the full width of the beam, or in another manner agreed upon by the Engineer
3) Allow concrete beam to cure.
4) Remove material used to create camber measurement locations (if used) and forms and detension beams.
5) Within three hours after prestress transfer, lift the entire beam and reset it back on the casting bed or on blocking in a holding area or in the storage yard and measure the elevation of the beam using survey equipment at the flat surfaces of the top of the top flange. Beams must be supported at the beam ends for survey shots.
6) Take the average of the end elevation readings and subtract from midspan elevation reading to determine initial camber.
7) Record initial camber value from step 6.
8) Submit initial camber of each beam to the District Materials Engineer.

DECISION PROCESS FOR PRETENSIONED PRESTRESSED CONCRETE BEAM CAMBER

Pretensioned Prestressed Concrete Beam design includes designed initial camber at release and camber after losses. The total PPC beam camber (ie: initial camber at release and after losses) is designed to theoretically occur when the PPC beam reaches 120 days of age. The theoretical total PPC beam camber at 120 days of age is based upon the support of the PPC beam in storage being at L/30 after initial camber measurement.

Steps in Decision Making Process for PPC beam camber:

1. In the fabrication of PPC beams, the precaster will form smooth surfaces at each centerline of bearing and midpoint of the beam length on the top flange as required by I.M. 570. Within 3 hours after prestress transfer, the precaster determines the initial camber at release by surveying the elevations of the top of the PPC beam on the smooth surfaces at each centerline of bearing of the beam and midpoint of the beam length while the PPC beam is supported at the ends of the beam. The initial camber at release measurement is compared to the specification requirement of +/- 30% of design initial camber at release and documented as complying or non-complying. If the initial camber at release complies with the +/- 30% camber tolerance and the PPC beam is not greater than 120 days of age, the PPC beam initial camber will be accepted by the Contracting Authority. If the initial camber at release does not comply with the +/- 30% camber tolerance, provisions for acceptance of the PPC beam camber will be determined later when the elevations of the beam are surveyed on the beam at the project site.

2. After the PPC beam has been delivered and erected on the bridge at the project site, the contractor will measure and mark the elevation locations on the top flange of the beam. Then the contractor will survey the top of beam elevations and provide the elevation information to the Engineer for evaluation of the bridge deck grades. The contractor will also provide the Engineer with the surveyed elevations of the as-constructed substructure beam seats which are reviewed to determine whether the beam seats are within the specification tolerance of +/- 0.02 feet of the plan beam seat elevations.

3. The Engineer calculates the bridge deck grades and makes any necessary deck grade adjustments to ensure that the deck haunches are within the plan allowable limits for haunch and embedment.

    - If the deck haunches are all within the allowable limits, no further action is required and the contractor can proceed with setting the deck forms for the bridge.
    - If the beam seat elevations and the PPC beam initial cambers are within the associated tolerances and the PPC beams are no greater than 120 days of age, but there are still areas of excess haunch after deck grade adjustments, the additional costs resulting from supplemental haunch reinforcing and additional haunch concrete will be paid by the Contracting Authority.
    - If the PPC beam initial cambers are out of tolerance, but the beam seat elevations and PPC beam final cambers are within the associated tolerances, but there are still areas of excess haunch after deck grade adjustments, the additional costs resulting from supplemental haunch reinforcing and additional haunch concrete will be paid by the Contracting Authority.
    - If the beam seat elevations or PPC beam initial cambers are outside the associated

tolerances and the PPC beam final cambers are out of tolerance which results in areas of excess haunch after deck grade adjustments, the additional costs resulting from supplemental haunch reinforcing and additional haunch concrete will be the responsibility of the contractor.

- If the PPC beam: 1) is older than 120 days, 2) final camber does not comply with the +/- 30% camber tolerance which results in supplemental haunch reinforcing/additional haunch concrete, and 3) delivery was not delayed by the Contracting Authority: the costs for supplemental haunch reinforcing and additional haunch concrete will be the responsibility of the contractor.

SWEEP MEASUREMENT PROCEDURES

1. Sweep shall be measured when the beam is not influenced by any differences in surface temperatures from face-to-face or side-to-side.
2. A beam should be able to meet the sweep tolerance without any external influence (temperature, sun) or any applied force of any kind.
3. The determination of sweep compliance shall be made no earlier than 48 hours and not until after the sweep correction techniques have been fully completed and the beam has been freed. The corrected beam must remain straight, in straight line parallel to the centerline of the beam and must comply with specification requirements of L/80 (Table 2407.03-3). For sweep determination, beam must be completely free. If the beam is checked on the bed, lifting and resetting shall be required.

   NOTE: “L” is the entire beam length in feet (meters).

SWEEP/EXCESSIVE SWEEP HANDLING PROCEDURES

The following procedures shall be followed in the event of prestressed concrete beams having developed sweep in excess of the allowable specification requirement tolerance of L/80. The procedures described in this section apply only to a uniform sweep with single lateral curvature producing a maximum offset at mid-point of the beam length.

A. Beams with excessive sweep greater than L/80 shall be corrected at the fabricator’s plant prior to shipping to the project site.

B. The fabricator may either tilt or lean the beam. This procedure will not require any prior approval.

C. A force may be applied to induce a maximum corrective lateral deflection as outlined below:

Beam Type and Size (English)	Sweep (inches)
C 55 - C 80	L/80
D 80 - D 95	3L/160
D 100 - D 110	L/40
LXC 55 - LXC 80	L/80
LXD 80 - LXD 105	3L/160
LXD 110 - LXD 120	L/40

This procedure will not require any prior approval.

D. If a force is to be applied other than what is outlined in paragraph "C", then this force needs to be predetermined and pre-approved by the Office of Bridges and Structures.

E. If approved, the intended force indicator must be carefully applied and must be monitored by means of a dial or a digital gauge. The monitor inspector shall make sure that the applied force does not exceed the predetermined limits. If the force exceeds the predetermined limits, then the beam shall be rejected.

F. A beam with twisted upper flange or lower flange shall not be accepted.

G. If approval is required for the jacking force, a written request shall be made to the District Materials Engineer. The District Materials Engineer will forward to the Office of Bridges and Structures for review and approval and with a copy to Central Materials.

H. Sweep in prestressed beam shall be measured at the web mid-point utilizing a cotton or nylon string tied to beam ends with sufficient tension. A conventional tape measure or a ruler may be used to measure the sweep.

*For further information, consult the "Sweep Correction/Conversion Verification Table," listed below.

Sweep Correction

CONVERSION VERIFICATION TABLE
C/D BEAMS

Beam ID		Length	Allowed Correction	
C	55	56.00	0.70	IN
C	59	60.17	0.75	IN
C	63	64.33	0.80	IN
C	67	68.50	0.86	IN
C	71	72.67	0.91	IN
C	75	76.83	0.96	IN
C	80	81.00	1.01	IN
D	80	81.00	1.52	IN
D	85	86.00	1.61	IN
D	90	91.00	1.71	IN
D	95	96.00	1.80	IN
D	100	101.00	1.89	IN
D	105	106.00	1.99	IN
D	110	111.00	2.78	IN

CONVERSION VERIFICATION TABLE
LXC/LXD BEAMS

Beam ID		Length	Allowed Correction
LXC	55	56.00	0.70 IN
LXC	59	60.17	0.75 IN
LXC	63	64.33	0.80 IN
LXC	67	68.50	0.86 IN
LXC	71	72.67	0.91 IN
LXC	75	76.83	0.96 IN
LXC	80	81.00	1.01 IN
LXD	80	81.00	1.52 IN
LXD	85	86.00	1.61 IN
LXD	90	91.00	1.71 IN
LXD	95	96.00	1.80 IN
LXD	100	101.00	1.89 IN
LXD	105	106.00	1.99 IN
LXD	110	111.00	2.78 IN
LXD	115	116.00	2.90 IN
LXD	120	121.00	3.03 IN

Sweep Correction - Field Procedures

For Beams that have developed sweep at the project site, only the applied force method described above may be used. The beam tilt or lean method may NOT be used in the field.

DOCUMENTATION

The precast and prestressed beam fabricator is required to maintain a file containing all required documentation for a minimum of seven years from the time the products are shipped for incorporation into a project.

Production records shall include as a minimum, the following data for each precast or prestress unit:

- Approved mix used
- Tensioning calculation
- Elongation measurements and gauge pressure
- Air temperature, at time of concrete placement
- Concrete temperature
- Curing temperature
- Release and shipping cylinder strengths
- Release and 28-day or shipping camber
- Fabrication Approval Date
- Dimensional check
- General appearance

- Repairs made
- Irregularities and remarks

REPORTING

The units are to be reported on Form #820905.

Certifications

The producer of precast and prestressed concrete beam units shall furnish, on each shipment day, a certified bill of materials or invoice which identifies the county, project number, contractor, and number of pieces. The certification of compliance shall be signed by a designated, responsible company representative and shall be stated as follows:

> "The materials itemized in this shipment are certified to be in compliance with the applicable AASHTO and/or ASTM requirements and Iowa Department of Transportation Standard Plans and Specifications, IMs and meet the Buy America requirements as described in IM 107 for all steel, iron products and coatings."

____
Authorized Signature and Date

One copy of the above-described document shall be forwarded to the Project Engineer on the day the item is delivered to the project. In addition, one copy shall be sent to the District Materials Engineer.

The producer of precast and prestressed concrete beam units shall furnish the follow up certification if the beam suffers any damage during shipment and the certification shall state as follows:

“The damaged beam in this shipment was repaired as per DOT approved repair plan and per Iowa Department of Transportation specifications and IMs.”

SHIPPING & ACCEPTANCE

Units shall be in full compliance with the specification requirements at the time of shipment to the project. Units with noncompliant initial camber are allowed to ship to the project. Units shall be inspected and stamped before leaving the fabricator yard.

Final acceptance of the units shall be at the project site by construction personnel.

PRECAST & PRESTRESSED CONCRETE BRIDGE UNITS
FABRICATOR APPROVAL APPLICATION

1. Has a current Plant Procedures Manual been approved by the DME? (Yes or no. If no, please explain.)

2. I agree to the following statements: Production operations will adhere to the Plant Procedures Manual. Updates and changes will be approved by the DME before use. (Yes or no. If no, please explain.)

3. Will Plant Quality Control forms be maintained during the course of production and be available for review by Iowa DOT personnel? (Yes or no. If no, please explain.)

4. Which company representative (position or name) will be responsible for distributing current, applicable specifications to production and quality control personnel?

5. Do quality control personnel inspect all phases of manufacturing (i.e., materials used, mixes, tensioning, pouring, curing, finishing, yardage and shipping)? (Yes or no. If no, please explain.)

6. Are the personnel responsible for quality control inspection Iowa DOT-certified? (Yes or no. If no, please explain.)

7. Please attach a flowchart of your company chain of command (See attached example.) including names, business addresses and phone numbers of appropriate management personnel to contact for problem resolution.

Indicate the District(s) for which you are seeking approval below.

1 2 3 4 5 6

Authorized Company Signature ____________________ Date ____________

DME Recommendations ____________________

DME Signature ____________________ Date ____________

Approval (Yes or No) Remarks ____________________

Materials Engineer Signature ____________________ Date ____________

TECHINICAL TRAINING & CERTIFICATION PROGRAM
PRESTRESS WORK HISTORY

NAME ____________________

ADDRESS ____________________

CITY ____________ STATE ____________ ZIP CODE ____________

CERTIFICATION NO. ____________ ACI NO. ____________ (If not Level I PCC)

WORK HISTORY

LOCATION OF PLANT ____________________

DUTIES PERFORMED:	DATE	HOURS

SUPERVISOR (Certified Prestress Technician) ____________________

COMPANY or AGENCY ____________________

REMARKS: ____________________

PLEASE FORWARD TO DISTRICT MATERIALS ENGINEER

REPAIR PROCEDURES & GUIDELINES
PRESTRESSED/PRECAST CONCRETE BRIDGE UNITS

Defective units or units damaged during handling or storage shall be evaluated for possible repair by the fabricator and the Iowa Department of Transportation as soon as practical (not to exceed 14 days). The fabricator shall propose repair procedures and list the brand name of patching material and submit a written request to the District Materials Engineer (DME) for approval and inclusion in the final beam inspection report. The District Materials Engineer, in consultation with the Construction and Materials Bureau, will have the final authority to accept, modify, or reject the repair procedure proposed by the fabricator.

Approved repair procedures that are standardized for reuse shall be documented in the plant-specific Quality Control Procedure Manual.

The following guidelines provide materials and procedures that may be used for repairs depending upon the extent of the defect or damage:

GUIDELINES FOR REPAIR OF AREAS WITH EXPOSED PRESTRESSING STRAND (STRUCTURAL TYPE)

Beams needing repair that have exposed prestress strands must undergo thorough inspection by District Materials personnel after removing forms, but before detensioning the strands. Before any repair work, exposed strands must be thoroughly cleaned while the beam stays under tension on the casting bed. A repair plan must be submitted for approval by the DME. The plan shall include a dimensioned diagram of the of the affected area, proposed repair material, and proposed repair procedures. The repair plan for both bonded and unbonded strands shall include:

1. Removing unsound concrete from the area. The repair area boundary shall be at least one-half inch deep and roughly perpendicular to the finished surface. Damage to prestress strand and reinforcement shall be avoided or addressed in the repair procedure.

2. Cleaning the exposed strands. Strands shall be free of rust, dust, grease, etc.. Use compressed air to remove dust and debris.

3. Using a repair material listed in IM 491.08 Appendix A or Appendix B, depending on application. Use of repair material not listed may be requested. A written request shall be submitted to and approved by the DME prior to beginning repairs.

4. Using repair material application procedures per manufacturer's recommendations and instructions. Use of repair procedures differing from the manufacturer may be requested. A written request shall be submitted to and approved by the DME prior to beginning repairs.

Repair plans that impact unbonded strands must also not reengage the strands. The DME may consult with the Bridges and Structures Bureau prior to approving such plans.

Some repairs may require approved anchoring devices as listed in Office of Materials IM 453.09.

GUIDELINES FOR REPAIR OF AREAS WITHOUT EXPOSED PRESTRESSING STRAND (NON-STRUCTURAL TYPE)

Beams needing repair that do not have exposed prestress strands may be repaired after the beam is detensioned and during the finishing process prior to shipping. These repairs are more routine in nature and generally do not require District Materials inspection prior to the fabricator developing a repair plan. The repair plan must be submitted for approval by the DME. The plan shall include a dimensioned diagram of the of the affected area, proposed repair material, and proposed repair procedures. The repair plan shall include*:*

1. Removing unsound concrete from the area. The repair area boundary shall be at least one-half inch deep and roughly perpendicular to the finished surface. Damage to prestress strand and reinforcement shall be avoided or addressed in the repair procedure.

2. Cleaning any exposed reinforcement. Reinforcement shall be free of rust, dust, grease, etc.. Use compressed air to remove dust and debris.

3. Using a repair material listed in IM 491.08 Appendix A or Appendix B, depending on application. Use of repair material not listed may be requested. A written request shall be submitted to and approved by the DME prior to beginning repairs.

4. Using repair material application procedures per manufacturer's recommendations and instructions. Use of repair procedures differing from the manufacturer may be requested. A written request shall be submitted to and approved by the DME prior to beginning repairs.

Some repairs may require approved anchoring devices as listed in Office of Materials IM 453.09.

REPAIR OF CRACKS USING EPOXY INJECTION

Use an approved epoxy resin as listed in Materials IM 491.19, Appendix B. Follow the manufacturer instructions for mixing and injecting the resin into the crack. The repair procedure shall include details of the location of injection ports and the proposed sequence of injecting the resin into the crack through the ports. Follow manufacturer recommendations for curing.

REPAIR PROCEDURES - CUT OFF STRANDS EXTENSION

Strand extensions that are cut off by mistake shall be repaired or may be substituted by leaving an uncut adjacent strand. Substitute strands shall have the same length and shape and maintain the vertical symmetry of the intended strand extension pattern. Consult with the DME to determine if substitute strands may be used.

If cut off strands must be repaired, use a strand of the same diameter and an approved epoxy-bonding grout as listed in IM 491.11 Appendix A that conforms to ASTM C-881 and/or AASHTO M-235 requirements. Follow the manufacturer recommendations and guidelines for preparation and mixing ratio. Prior approval of the DME shall be required.

The following procedures shall be used:

1. Drill 6 in. deep hole approximately 1/8 inch greater in diameter than the replacement strand, next to the cut-off strand.

2. Clean the hole by washing it and blowing it dry.

4. Fill the hole with a polymer grout listed in IM 491.11 Appendix A.

5. Insert the strand.

6. Cure per manufacturer's recommendations.

7. Bend the strand at the required length from the end of the beam. (Heating and bending of the strand is not allowed.)

Strand Cutoff Length
Strand cutoff length on ends of beams cannot vary by more than ±1/2 in. of the specified length.

REPAIR SITE CONTAINMENT
All completed spall and void repair sites shall be reviewed by the DME for possible containment measures. Repair site containment is intended to reduce the opportunity for dislodged repair material to fall on occupied areas under the bridge.

Containment measures shall typically be required for repair sites with any of the following characteristics:

1. Located over the shoulder-to-shoulder roadway surface.
2. Located over or within 10 feet of a current or proposed public path.
3. Located over or within 10 feet of railroad tracks.
4. Located over DNR-designated state water trails and paddling routes. See website for locations. https://www.iowadnr.gov/Things-to-Do/Canoeing-Kayaking/Where-to-Paddle
5. Located over parking areas.
6. Other locations as identified by the Engineer.

Repair site containment shall use a Fiber Reinforced Polymer (FRP) repair system in accordance with Materials I.M. 491.25, Appendix A. Follow the manufacturer's recommendations and guidelines for material preparation and use. When installed strictly for repair site containment purposes, manufacturer-trained/certified installer credentials are not required.

The FRP fabric shall extend at least 12 inches beyond the perimeter of the repair. The concrete surface under the fabric shall be free from fins, sharp edges, and protrusions that will cause voids or depressions behind the FRP fabric. The surface shall also be grouted to fill any voids greater than 0.5 inches in diameter and 0.125 inches in depth. Grout shall be fully cured before beginning installation of the FRP system.

COLD WEATHER PLACEMENT

The following chart will be used to determine allowable temperature and wind conditions for concrete placement during cold weather. Air temperature and wind velocity measurement should reasonably represent conditions at the site of concrete placement. Apply this IM 570 Appendix D for both LRFD and LX beams.

When the air temperature is below 35°F determine the wind velocity using available wind velocity measuring equipment. Velocity determination should disregard wind gust and be based on a steady, reasonably sustained wind velocity. When the equivalent temperature is 5°F or above and is expected to remain above 5°F for the time required to complete the units involved, concrete may be placed provided the forms are covered and preheated and the concrete temperature is controlled. All forms must be covered with a suitable cover prior to concrete placement and the entire line preheated to at least 40°F. The entire preheated line shall include forms, strands and reinforcing steel). Remove the covers only where concrete is being placed or finished and immediately recover the finished units. The concrete temperature in the forms must be maintained at 40° or higher at all times during the concreting operation. This procedure shall be followed until the concrete for the entire line has been placed.

Air Temp. °F	Wind Speed Mph	Air Temp. °F	Wind Speed Mph
30	100	16	9
28	88	14	6
26	59	12	4
24	40	10	2
22	28	8	2
20	19	6	1
18	13	5	1

When the wind velocity is greater than indicated on this chart for any corresponding air temperature, and the equivalent temperature is below 5°F No concrete shall be placed when the air temperature or equivalent temperature is below 5°F.

If it is desired to place concrete when the air temperature or equivalent temperature is below 5°F suitable housing would be required to control the surrounding temperature. Approval of this housing system would be based on consideration of the temperature effect on the entire line.

NOTE: Plant approval by the DME is required for cold weather concrete placement.

PRECAUTIONARY NOTES

- Pallets may buckle due to temperature changes. The condition of the line should be checked immediately before commencement of concrete placement.
- Ensure no frozen material is incorporated.

- All snow, ice, and frost shall be removed from steel and forms.

- After placement and vibration, the concrete shall be allowed to attain its initial set before steam is applied. Otherwise, the elevated temperature may have a detrimental effect on the concrete strength. (Refer to Specification 2407.03, D.)

Steam jets shall not discharge directly onto the concrete, forms, or test cylinder.

COLD WEATHER WORK
Air temperature and wind velocity measurement shall reasonably represent conditions, which exists at the fabricator's site. Concrete placement, curing, inspection and major prestress activities shall meet the requirements of the standard specifications.

COLD WEATHER STRESSING
The maximum jacking stress in prestressing strand shall not exceed 80% of the specified minimum ultimate tensile strength (0.80 f'_s), including the allowances for seating losses and temperature differences.

Prestressing strand that is subjected to stresses exceeding (0.80 f'_s), including the stresses resulting from temperature drop after seating, will be considered unacceptable and subject to rejection. Enclosure and heating of the strands shall be utilized to minimize cold weather stressing problems.

When computing the effect of temperature drop after seating, the allowance for live end seating loss may be added to the available stress for temperature drop. The strand stress at seating, as determined by elongation measurement, shall be considered the base stress when computing the effect of temperature drop. The calculation of stress due to elongation measurement shall be based upon the actual strand area and the modulus of elasticity.

In order to better facilitate fabrication of prestressed beams during cold weather the following alternatives will be allowed:

NOTE: Overstressing of the strand during the loading procedure shall not be permitted.

1. Substitution of 1/2 in. plus strand (nominal area = 0.167 in.^{2} (one for one, for 1/2 in. regular strand (nominal area = 0.153 in.^{2} is permissible. This substitution will enable the same total prestress force to be attained at a significantly lower strand stress level, thereby providing a greater range of stress available to compensate for temperature differentials. The 1/2 in. plus strand shall be Grade 270 low relaxation strand complying with ASTM A416/A416M, with a minimum breaking strength of 183.7.

   The substitution of 1/2 in. plus strand may be made for all strands in the beam or just for the deflected strands only.

   The 1/2 in. plus strand substitution alternative is applicable to all beams that specify 1/2 in. regular strands on the beam plan. The plan strand pattern shall not be changed. **NOTE:** This alternative is not applicable to the bulb-tee beams.

2. Overnight heating or preheating of the strands is an option for cold weather stressing.

3. Additional strands, of the plan-specified size, may be added to the plan strand pattern. This will enable the plan-specified total prestress force to be attained at a lower strand stress level. The following table lists the details for this alternative for the standard beams that specify the initial prestress at 75 % of f'_s. (f'_s = specified minimum tensile strength of the strand.) It is assumed that the standard beams that specify an initial prestress of 72.62% of f'_s will not present a significant problem of cold weather stressing. However, if the producer wishes to use this alternative for beams that specify the 72.62% of f'_s prestress level, the producer shall submit such a request to the District Materials Engineer, along with the beam stress calculations and details to support the request for approval prior to its use.

STANDARD BEAMS THAT SPECIFY THE INITIAL PRESTRESS AT 75% OF f'_s

BEAMS	ADDED STRANDS (1)	TOTAL STRANDS (2)	Y_b IN. (3)	TOTAL INITIAL PRESTRESS	% of f'_s (5)
LXA55	2	24	6	SEE NOTE (4)	68.7
LXB67	2	28	6		69.6
LXC75	2	28	4		69.6
LXD80	2	32	4		70.3
LXD90	2	30	4		70.0
LXD95	2	34	8		70.6
LXD100	2	38	8		71.0
LXD105	2	42	8		71.4
LXD110	2	48	10		71.8
BT120	2	36	6 3/8		70.8
BT125	2	40	6 3/8		71.3
BT130	2	42	6 3/8		71.4
BT135	2	46	6 3/8		71.7
BT140	2	50	6 3/8		72.0

NOTE 1: All added strands shall be straight strands, and shall be the same size as the plan-specified beam strands.

NOTE 2: The strand pattern shall be the same as the standard plan, except for the additional straight strands, which shall be located as herein specified.

NOTE 3: The distance from the bottom of the beam to the centerline of added strands. Strands shall be placed laterally two inches centerline to centerline from other strands and symmetrically, one on each side of the beam centerline.

NOTE 4: Total initial prestress shall be the same as specified on the standard plan.

NOTE 5: Initial strand stress as a percent of f'_s (if strands are added).

The proposed and the recommended procedures [the enclosure and the preheating of the strands, the use of the 1/2 in + strands and/or the use of the additional strands] shall be considered as incidental to the cost of the fabrication of the beam.

PROCEDURE FOR CASTING DIFFERENT LENGTH PRECAST/PRESTRESS CONCRETE BRIDGE UNITS
(Combined Beam Pours)

SCOPE:
To establish procedures for the fabrication of beams with different lengths on one casting bed setup. Any deviation from the beam design standard or the Combination Pour Charts is not allowed.

This procedure allows the casting of two different length beams together in the same line in accordance with Combination Pour Charts. For example, a BTC100 beam may be cast with a BTC120 beam with the following modifications made to the BTC100 beam:

- The number of straight strands and deflected strands used for the BTC100 beam shall equal the amount required for the BTC120 beam (44 straight strands and 10 deflected strands).
- The deflected strands for the BTC100 beam are raised by 20 inches.
- Compressive strength at release and at 28 days are increased to 8000 psi and 10000 psi, respectively, for the BTC100 beam.
- Beam end debonding configuration for the BTC120 shall be used at the BTC100 beam ends.

Use of a next longer beam strand pattern may result in camber increase in the modified beams. For example, the calculated camber at the time of release for a BTC100 beam (with a BTC120 strand pattern) will increase by approximately 0.21 inches. Whenever such beam modifications are used, the fabricator shall notify the District Materials Engineer prior to fabrication. No additional acknowledgements will be required as the fabricator will comply with the combination pour charts.

		A 30	A 34	A 38	A 42	A 46	A 50	A 55
A 30	Straight Strands	8	9	10	7	8	9	10
	Deflected Strands	0	0	0	2	2	3	3
	Distance Deflected Strands Raised (in.)	-	-	-	6	4	8	10
	Release Strength (psi)	4500	4500	4500	4500	6000	6000	6000
	28 Day Strength (psi)	5000	5000	5000	5000	7000	7000	7000
	Design Camber @ Release (Plan-in.)	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Design Camber @ Release (Modified-in.)	0.13	0.17	0.21	0.29	0.30	0.33	0.36
	Absolute Difference in Camber @ Release (in.)	0.00	0.04	0.08	0.16	0.17	0.20	0.23
A 34	Straight Strands		9	10	7	8	9	10
	Deflected Strands		0	0	2	2	3	3
	Distance Deflected Strands Raised (in.)		-	-	4	4	8	10
	Release Strength (psi)		4500	4500	4500	6000	6000	6000
	28 Day Strength (psi)		5000	5000	5000	7000	7000	7000
	Design Camber @ Release (Plan-in.)		0.21	0.21	0.21	0.21	0.21	0.21
	Design Camber @ Release (Modified-in.)		0.21	0.26	0.37	0.39	0.42	0.48
	Absolute Difference in Camber @ Release (in.)		0.00	0.05	0.16	0.18	0.21	0.27
A 38	Straight Strands			10	7	8	9	10
	Deflected Strands			0	2	2	3	3
	Distance Deflected Strands Raised (in.)			-	2	0	6	8
	Release Strength (psi)			4500	4500	6000	6000	6000
	28 Day Strength (psi)			5000	5000	7000	7000	7000
	Design Camber @ Release (Plan-in.)			0.30	0.30	0.30	0.30	0.30
	Design Camber @ Release (Modified-in.)			0.30	0.46	0.48	0.53	0.58
	Absolute Difference in Camber @ Release (in.)			0.00	0.16	0.18	0.23	0.28
A 42	Straight Strands				7	8	9	10
	Deflected Strands				2	2	3	3
	Distance Deflected Strands Raised (in.)				0	0	4	6
	Release Strength (psi)				4500	6000	6000	6000
	28 Day Strength (psi)				5000	7000	7000	7000
	Design Camber @ Release (Plan-in.)				0.59	0.59	0.59	0.59
	Design Camber @ Release (Modified-in.)				0.59	0.57	0.66	0.72
	Absolute Difference in Camber @ Release (in.)				0.00	0.02	0.07	0.13
A 46	Straight Strands					8	9	10
	Deflected Strands					2	3	3
	Distance Deflected Strands Raised (in.)					0	2	4
	Release Strength (psi)					6000	6000	6000
	28 Day Strength (psi)					7000	7000	7000
	Design Camber @ Release (Plan-in.)					0.60	0.60	0.60
	Design Camber @ Release (Modified-in.)					0.60	0.80	0.87
	Absolute Difference in Camber @ Release (in.)					0.00	0.20	0.27

		A 30	A 34	A 38	A 42	A 46	A 50	A 55
A 50	Straight Strands						9	10
	Deflected Strands						3	3
	Distance Deflected Strands Raised (in.)						0	2
	Release Strength (psi)						6000	6000
	28 Day Strength (psi)						7000	7000
	Design Camber @ Release (Plan-in.)						0.88	0.88
	Design Camber @ Release (Modified-in.)						0.88	1.03
	Absolute Difference in Camber @ Release (in.)						0.00	0.15
A 55	Straight Strands							10
	Deflected Strands							3
	Distance Deflected Strands Raised (in.)							0
	Release Strength (psi)							6000
	28 Day Strength (psi)							7000
	Design Camber @ Release (Plan-in.)							1.17
	Design Camber @ Release (Modified-in.)							1.17
	Absolute Difference in Camber @ Release (in.)							0.00

		B 34	B 38	B 42	B 46	B 50	B 55	B 59	B 63	B 67
B 34	Straight Strands	8	8	10	7	8	8			
	Deflected Strands	0	0	0	2	2	3			
	Distance Deflected Strands Raised (in.)	-	-	-	4	8	6			
	Release Strength (psi)	4500	4500	4500	4500	4500	6000			
	28 Day Strength (psi)	5000	5000	5000	5000	5000	7000			
	Design Camber @ Release (Plan-in.)	0.10	0.10	0.10	0.10	0.10	0.10			
	Design Camber @ Release (Modified-in.)	0.10	0.10	0.17	0.24	0.26	0.28			
	Absolute Difference in Camber @ Release (in.)	0.00	0.00	0.07	0.14	0.16	0.18			
B 38	Straight Strands		8	10	7	8	8			
	Deflected Strands		0	0	2	2	3			
	Distance Deflected Strands Raised (in.)		-	-	4	6	6			
	Release Strength (psi)		4500	4500	4500	4500	6000			
	28 Day Strength (psi)		5000	5000	5000	5000	7000			
	Design Camber @ Release (Plan-in.)		0.11	0.11	0.11	0.11	0.11			
	Design Camber @ Release (Modified-in.)		0.11	0.20	0.29	0.32	0.34			
	Absolute Difference in Camber @ Release (in.)		0.00	0.09	0.18	0.21	0.23			
B 42	Straight Strands			10	7	8	8	10		
	Deflected Strands			0	2	2	3	3		
	Distance Deflected Strands Raised (in.)			-	2	4	4	10		
	Release Strength (psi)			4500	4500	4500	6000	6000		
	28 Day Strength (psi)			5000	5000	5000	7000	7000		
	Design Camber @ Release (Plan-in.)			0.23	0.23	0.23	0.23	0.23		
	Design Camber @ Release (Modified-in.)			0.23	0.34	0.38	0.42	0.47		
	Absolute Difference in Camber @ Release (in.)			0.00	0.11	0.15	0.19	0.24		
B 46	Straight Strands				7	8	8	10		
	Deflected Strands				2	2	3	3		
	Distance Deflected Strands Raised (in.)				0	0	2	6		
	Release Strength (psi)				4500	4500	6000	6000		
	28 Day Strength (psi)				5000	5000	7000	7000		
	Design Camber @ Release (Plan-in.)				0.42	0.42	0.42	0.42		
	Design Camber @ Release (Modified-in.)				0.42	0.46	0.51	0.47		
	Absolute Difference in Camber @ Release (in.)				0.00	0.04	0.09	0.05		
B 50	Straight Strands					8	8	10	12	
	Deflected Strands					2	3	3	3	
	Distance Deflected Strands Raised (in.)					0	0	4	8	
	Release Strength (psi)					4500	6000	6000	6000	
	28 Day Strength (psi)					5000	7000	7000	7000	
	Design Camber @ Release (Plan-in.)					0.55	0.55	0.55	0.55	
	Design Camber @ Release (Modified-in.)					0.55	0.60	0.69	0.79	
	Absolute Difference in Camber @ Release (in.)					0.00	0.05	0.14	0.24	

		B 34	B 38	B 42	B 46	B 50	B 55	B 59	B 63	B 67
B 55	Straight Strands						8	10	12	
	Deflected Strands						3	3	3	
	Distance Deflected Strands Raised (in.)						0	2	8	
	Release Strength (psi)						6000	6000	6000	
	28 Day Strength (psi)						7000	7000	7000	
	Design Camber @ Release (Plan-in.)						0.62	0.62	0.62	
	Design Camber @ Release (Modified-in.)						0.62	0.80	0.88	
	Absolute Difference in Camber @ Release (in.)						0.00	0.18	0.26	
B 59	Straight Strands							10	12	14
	Deflected Strands							3	3	3
	Distance Deflected Strands Raised (in.)							0	4	10
	Release Strength (psi)							6000	6000	6000
	28 Day Strength (psi)							7000	7000	7000
	Design Camber @ Release (Plan-in.)							0.85	0.85	0.85
	Design Camber @ Release (Modified-in.)							0.85	1.04	1.13
	Absolute Difference in Camber @ Release (in.)							0.00	0.19	0.28
B 63	Straight Strands								12	14
	Deflected Strands								3	3
	Distance Deflected Strands Raised (in.)								0	2
	Release Strength (psi)								6000	6000
	28 Day Strength (psi)								7000	7000
	Design Camber @ Release (Plan-in.)								1.12	1.12
	Design Camber @ Release (Modified-in.)								1.12	1.39
	Absolute Difference in Camber @ Release (in.)								0.00	0.27
B 67	Straight Strands									14
	Deflected Strands									3
	Distance Deflected Strands Raised (in.)									0
	Release Strength (psi)									6000
	28 Day Strength (psi)									7000
	Design Camber @ Release (Plan-in.)									1.43
	Design Camber @ Release (Modified-in.)									1.43
	Absolute Difference in Camber @ Release (in.)									0.00

		C 30	C 34	C 38	C 42	C 46	C 50	C 55	C 59	C 63	C 67	C 71	C 75	C 80
C 30	Straight Strands	8	10	10	10	10	12							
	Deflected Strands	0	0	0	0	0	0							
	Distance Deflected Strands Raised (in.)	-	-	-	-	-	-							
	Release Strength (psi)	4500	4500	4500	4500	4500	4500							
	28 Day Strength (psi)	5000	5000	5000	5000	5000	5000							
	Design Camber @ Release (Plan-in.)	0.05	0.05	0.05	0.05	0.05	0.05							
	Design Camber @ Release (Modified-in.)	0.05	0.08	0.08	0.08	0.08	0.12							
	Absolute Difference in Camber @ Release (in.)	0.00	0.03	0.03	0.03	0.03	0.07							
C 34	Straight Strands		10	10	10	10	12							
	Deflected Strands		0	0	0	0	0							
	Distance Deflected Strands Raised (in.)		-	-	-	-	-							
	Release Strength (psi)		4500	4500	4500	4500	4500							
	28 Day Strength (psi)		5000	5000	5000	5000	5000							
	Design Camber @ Release (Plan-in.)		0.10	0.10	0.10	0.10	0.10							
	Design Camber @ Release (Modified-in.)		0.10	0.10	0.10	0.10	0.15							
	Absolute Difference in Camber @ Release (in.)		0.00	0.00	0.00	0.00	0.05							
C 38	Straight Strands			10	10	10	12							
	Deflected Strands			0	0	0	0							
	Distance Deflected Strands Raised (in.)			-	-	-	-							
	Release Strength (psi)			4500	4500	4500	4500							
	28 Day Strength (psi)			5000	5000	5000	5000							
	Design Camber @ Release (Plan-in.)			0.11	0.11	0.11	0.11							
	Design Camber @ Release (Modified-in.)			0.11	0.12	0.12	0.18							
	Absolute Difference in Camber @ Release (in.)			0.00	0.01	0.01	0.07							
C 42	Straight Strands				10	10	12	14	14					
	Deflected Strands				0	0	0	0	0					
	Distance Deflected Strands Raised (in.)				-	-	-	-	-					
	Release Strength (psi)				4500	4500	4500	4500	4500					
	28 Day Strength (psi)				5000	5000	5000	5000	5000					
	Design Camber @ Release (Plan-in.)				0.13	0.13	0.13	0.13	0.13					
	Design Camber @ Release (Modified-in.)				0.13	0.13	0.21	0.27	0.27					
	Absolute Difference in Camber @ Release (in.)				0.00	0.00	0.08	0.14	0.14					
C 46	Straight Strands					10	12	14	14					
	Deflected Strands					0	0	0	0					
	Distance Deflected Strands Raised (in.)					-	-	-	-					
	Release Strength (psi)					4500	4500	4500	4500					
	28 Day Strength (psi)					5000	5000	5000	5000					
	Design Camber @ Release (Plan-in.)					0.14	0.14	0.14	0.14					
	Design Camber @ Release (Modified-in.)					0.14	0.23	0.31	0.31					
	Absolute Difference in Camber @ Release (in.)					0.00	0.09	0.17	0.17					

		C 30	C 34	C 38	C 42	C 46	C 50	C 55	C 59	C 63	C 67	C 71	C 75	C 80
C 50	Straight Strands						12	14	14	16				
	Deflected Strands						0	0	0	0				
	Distance Deflected Strands Raised (in.)						-	-	-	-				
	Release Strength (psi)						4500	4500	4500	4500				
	28 Day Strength (psi)						5000	5000	5000	5000				
	Design Camber @ Release (Plan-in.)						0.26	0.26	0.26	0.26				
	Design Camber @ Release (Modified-in.)						0.26	0.34	0.34	0.44				
	Absolute Difference in Camber @ Release (in.)						0.00	0.08	0.08	0.18				
C 55	Straight Strands							14	14	16	18	14		
	Deflected Strands							0	0	0	0	4		
	Distance Deflected Strands Raised (in.)							-	-	-	-	16		
	Release Strength (psi)							4500	4500	4500	4500	5000		
	28 Day Strength (psi)							5000	5000	5000	5000	6000		
	Design Camber @ Release (Plan-in.)							0.37	0.37	0.37	0.37	0.37		
	Design Camber @ Release (Modified-in.)							0.37	0.37	0.49	0.59	0.54		
	Absolute Difference in Camber @ Release (in.)							0.00	0.00	0.12	0.22	0.17		
C 59	Straight Strands								14	16	18	14		
	Deflected Strands								0	0	0	4		
	Distance Deflected Strands Raised (in.)								-	-	-	14		
	Release Strength (psi)								4500	4500	4500	5000		
	28 Day Strength (psi)								5000	5000	5000	6000		
	Design Camber @ Release (Plan-in.)								0.39	0.39	0.39	0.39		
	Design Camber @ Release (Modified-in.)								0.39	0.52	0.64	0.61		
	Absolute Difference in Camber @ Release (in.)								0.00	0.13	0.25	0.22		
C 63	Straight Strands									16	18	14	14	16
	Deflected Strands									0	0	4	6	6
	Distance Deflected Strands Raised (in.)									-	-	8	10	14
	Release Strength (psi)									4500	4500	5000	5000	5000
	28 Day Strength (psi)									5000	5000	6000	6000	6000
	Design Camber @ Release (Plan-in.)									0.56	0.56	0.56	0.56	0.56
	Design Camber @ Release (Modified-in.)									0.56	0.69	0.74	0.74	0.76
	Absolute Difference in Camber @ Release (in.)									0.00	0.13	0.18	0.18	0.20
C 67	Straight Strands										18	14	14	16
	Deflected Strands										0	4	6	6
	Distance Deflected Strands Raised (in.)										-	4	6	10
	Release Strength (psi)										4500	5000	5000	5000
	28 Day Strength (psi)										5000	6000	6000	6000
	Design Camber @ Release (Plan-in.)										0.73	0.73	0.73	0.73
	Design Camber @ Release (Modified-in.)										0.73	0.85	0.88	0.90
	Absolute Difference in Camber @ Release (in.)										0.00	0.12	0.15	0.17

		C 30	C 34	C 38	C 42	C 46	C 50	C 55	C 59	C 63	C 67	C 71	C 75	C 80
C 71	Straight Strands											14	14	16
	Deflected Strands											4	6	6
	Distance Deflected Strands Raised (in.)											0	0	4
	Release Strength (psi)											5000	5000	5000
	28 Day Strength (psi)											6000	6000	6000
	Design Camber @ Release (Plan-in.)											1.01	1.01	1.01
	Design Camber @ Release (Modified-in.)											1.01	1.08	1.10
	Absolute Difference in Camber @ Release (in.)											0.00	0.07	0.09
C 75	Straight Strands												14	16
	Deflected Strands												6	6
	Distance Deflected Strands Raised (in.)												0	2
	Release Strength (psi)												5000	5000
	28 Day Strength (psi)												6000	6000
	Design Camber @ Release (Plan-in.)												1.20	1.20
	Design Camber @ Release (Modified-in.)												1.20	1.22
	Absolute Difference in Camber @ Release (in.)												0.00	0.02
C 80	Straight Strands													16
	Deflected Strands													6
	Distance Deflected Strands Raised (in.)													0
	Release Strength (psi)													5000
	28 Day Strength (psi)													6000
	Design Camber @ Release (Plan-in.)													1.40
	Design Camber @ Release (Modified-in.)													1.40
	Absolute Difference in Camber @ Release (in.)													0.00

		D 35	D 40	D 45	D 50	D 55	D 60	D 65	D 70	D 75	D 80	D 85	D 90	D 95	D 100	D 105	D 110
D 35	Straight Strands	10	10	12	12	12	14										
	Deflected Strands	0	0	0	0	0	0										
	Distance Deflected Strands Raised (in.)	-	-	-	-	-	-										
	Release Strength (psi)	4500	4500	4500	4500	4500	4500										
	28 Day Strength (psi)	5000	5000	5000	5000	5000	5000										
	Design Camber @ Release (Plan-in.)	0.07	0.07	0.07	0.07	0.07	0.07										
	Design Camber @ Release (Modified-in.)	0.07	0.07	0.10	0.11	0.11	0.14										
	Absolute Difference in Camber @ Release (in.)	0.00	0.00	0.03	0.04	0.04	0.07										
D 40	Straight Strands		10	12	12	12	14										
	Deflected Strands		0	0	0	0	0										
	Distance Deflected Strands Raised (in.)		-	-	-	-	-										
	Release Strength (psi)		4500	4500	4500	4500	4500										
	28 Day Strength (psi)		5000	5000	5000	5000	5000										
	Design Camber @ Release (Plan-in.)		0.08	0.08	0.08	0.08	0.08										
	Design Camber @ Release (Modified-in.)		0.08	0.12	0.13	0.14	0.18										
	Absolute Difference in Camber @ Release (in.)		0.00	0.04	0.05	0.06	0.10										
D 45	Straight Strands			12	12	12	14										
	Deflected Strands			0	0	0	0										
	Distance Deflected Strands Raised (in.)			-	-	-	-										
	Release Strength (psi)			4500	4500	4500	4500										
	28 Day Strength (psi)			5000	5000	5000	5000										
	Design Camber @ Release (Plan-in.)			0.14	0.14	0.14	0.14										
	Design Camber @ Release (Modified-in.)			0.14	0.15	0.16	0.21										
	Absolute Difference in Camber @ Release (in.)			0.00	0.01	0.02	0.07										
D 50	Straight Strands				12	12	14	8	8								
	Deflected Strands				0	0	0	4	6								
	Distance Deflected Strands Raised (in.)				-	-	-	2	4								
	Release Strength (psi)				4500	4500	4500	4500	4500								
	28 Day Strength (psi)				5000	5000	5000	5000	5000								
	Design Camber @ Release (Plan-in.)				0.17	0.17	0.17	0.17	0.17								
	Design Camber @ Release (Modified-in.)				0.17	0.18	0.24	0.27	0.28								
	Absolute Difference in Camber @ Release (in.)				0.00	0.01	0.07	0.10	0.11								
D 55	Straight Strands					12	14	8	8								
	Deflected Strands					0	0	4	6								
	Distance Deflected Strands Raised (in.)					-	-	0	0								
	Release Strength (psi)					4500	4500	4500	4500								
	28 Day Strength (psi)					5000	5000	5000	5000								
	Design Camber @ Release (Plan-in.)					0.19	0.19	0.19	0.19								
	Design Camber @ Release (Modified-in.)					0.19	0.26	0.32	0.35								
	Absolute Difference in Camber @ Release (in.)					0.00	0.07	0.13	0.16								

		D 35	D 40	D 45	D 50	D 55	D 60	D 65	D 70	D 75	D 80	D 85	D 90	D 95	D 100	D 105	D 110
D 60	Straight Strands						14	8	8	12							
	Deflected Strands						0	4	6	6							
	Distance Deflected Strands Raised (in.)						-	0	0	6							
	Release Strength (psi)						4500	4500	4500	4500							
	28 Day Strength (psi)						5000	5000	5000	5000							
	Design Camber @ Release (Plan-in.)						0.28	0.28	0.28	0.28							
	Design Camber @ Release (Modified-in.)						0.28	0.35	0.38	0.50							
	Absolute Difference in Camber @ Release (in.)						0.00	0.07	0.10	0.22							
D 65	Straight Strands							8	8	12	12						
	Deflected Strands							4	6	6	6						
	Distance Deflected Strands Raised (in.)							0	0	4	6						
	Release Strength (psi)							4500	4500	4500	4500						
	28 Day Strength (psi)							5000	5000	5000	5000						
	Design Camber @ Release (Plan-in.)							0.40	0.40	0.40	0.40						
	Design Camber @ Release (Modified-in.)							0.40	0.41	0.58	0.57						
	Absolute Difference in Camber @ Release (in.)							0.00	0.01	0.18	0.17						
D 70	Straight Strands								8	12	12	14					
	Deflected Strands								6	6	6	6					
	Distance Deflected Strands Raised (in.)								0	2	4	14					
	Release Strength (psi)								4500	4500	4500	4500					
	28 Day Strength (psi)								5000	5000	5000	5000					
	Design Camber @ Release (Plan-in.)								0.47	0.47	0.47	0.47					
	Design Camber @ Release (Modified-in.)								0.47	0.77	0.64	0.68					
	Absolute Difference in Camber @ Release (in.)								0.00	0.30	0.17	0.21					
D 75	Straight Strands									12	12	14	16				
	Deflected Strands									6	6	6	6				
	Distance Deflected Strands Raised (in.)									0	0	4	10				
	Release Strength (psi)									4500	4500	4500	4500				
	28 Day Strength (psi)									5000	5000	5000	5000				
	Design Camber @ Release (Plan-in.)									0.77	0.77	0.77	0.77				
	Design Camber @ Release (Modified-in.)									0.77	0.75	0.86	0.90				
	Absolute Difference in Camber @ Release (in.)									0.00	0.02	0.09	0.13				
D 80	Straight Strands										12	14	16	18			
	Deflected Strands										6	6	6	6			
	Distance Deflected Strands Raised (in.)										0	2	8	18			
	Release Strength (psi)										4500	4500	4500	4500			
	28 Day Strength (psi)										5000	5000	5000	5000			
	Design Camber @ Release (Plan-in.)										0.83	0.83	0.83	0.83			
	Design Camber @ Release (Modified-in.)										0.83	0.95	0.99	0.97			
	Absolute Difference in Camber @ Release (in.)										0.00	0.12	0.16	0.14			

		D 35	D 40	D 45	D 50	D 55	D 60	D 65	D 70	D 75	D 80	D 85	D 90	D 95	D 100	D 105	D 110
D 85	Straight Strands											14	16	18	22		
	Deflected Strands											6	6	6	6		
	Distance Deflected Strands Raised (in.)											0	0	8	22		
	Release Strength (psi)											4500	4500	4500	6000		
	28 Day Strength (psi)											5000	5000	5000	7500		
	Design Camber @ Release (Plan-in.)											1.10	1.10	1.10	1.10		
	Design Camber @ Release (Modified-in.)											1.10	1.20	1.24	1.36		
	Absolute Difference in Camber @ Release (in.)											0.00	0.10	0.14	0.26		
D 90	Straight Strands												16	18	22	26	
	Deflected Strands												6	6	6	6	
	Distance Deflected Strands Raised (in.)												0	4	14	22	
	Release Strength (psi)												4500	4500	6000	6000	
	28 Day Strength (psi)												5000	5000	7500	7500	
	Design Camber @ Release (Plan-in.)												1.32	1.32	1.32	1.32	
	Design Camber @ Release (Modified-in.)												1.32	1.38	1.62	1.60	
	Absolute Difference in Camber @ Release (in.)												0.00	0.06	0.30	0.28	
D 95	Straight Strands													18	22	26	
	Deflected Strands													6	6	6	
	Distance Deflected Strands Raised (in.)													0	8	12	
	Release Strength (psi)													4500	6000	6000	
	28 Day Strength (psi)													5000	7500	7500	
	Design Camber @ Release (Plan-in.)													1.61	1.61	1.61	
	Design Camber @ Release (Modified-in.)													1.61	1.85	1.91	
	Absolute Difference in Camber @ Release (in.)													0.00	0.24	0.30	
D 100	Straight Strands														22	26	28
	Deflected Strands														6	6	6
	Distance Deflected Strands Raised (in.)														0	4	8
	Release Strength (psi)														6000	6000	6000
	28 Day Strength (psi)														7500	7500	7500
	Design Camber @ Release (Plan-in.)														1.96	1.96	1.96
	Design Camber @ Release (Modified-in.)														1.96	2.21	2.24
	Absolute Difference in Camber @ Release (in.)														0.00	0.25	0.28
D 105	Straight Strands															26	28
	Deflected Strands															6	6
	Distance Deflected Strands Raised (in.)															0	4
	Release Strength (psi)															6000	6500
	28 Day Strength (psi)															7500	7500
	Design Camber @ Release (Plan-in.)															2.23	2.23
	Design Camber @ Release (Modified-in.)															2.23	2.44
	Absolute Difference in Camber @ Release (in.)															0.00	0.21

		D 35	D 40	D 45	D 50	D 55	D 60	D 65	D 70	D 75	D 80	D 85	D 90	D 95	D 100	D 105	D 110
D 110	Straight Strands																28
	Deflected Strands																6
	Distance Deflected Strands Raised (in.)																0
	Release Strength (psi)																6500
	28 Day Strength (psi)																7500
	Design Camber @ Release (Plan-in.)																2.74
	Design Camber @ Release (Modified-in.)																2.74
	Absolute Difference in Camber @ Release (in.)																0.00

		BTB 30	BTB 35	BTB 40	BTB 45	BTB 50	BTB 55	BTB 60	BTB 65	BTB 70	BTB 75	BTB 80	BTB 85	BTB 90	*BTB 95	*BTB 100	*BTB 105
BTB 30	Straight Strands	8	10	12	12												
	Deflected Strands	0	0	0	0												
	Distance Deflected Strands Raised (in.)	-	-	-	-												
	Release Strength (psi)	4500	4500	4500	4500												
	28 Day Strength (psi)	5000	5000	5000	5000												
	Design Camber @ Release (Plan-in.)	0.12	0.12	0.12	0.12												
	Design Camber @ Release (Modified-in.)	0.12	0.16	0.20	0.20												
	Absolute Difference in Camber @ Release (in.)	0.00	0.04	0.08	0.08												
BTB 35	Straight Strands		10	12	12												
	Deflected Strands		0	0	0												
	Distance Deflected Strands Raised (in.)		-	-	-												
	Release Strength (psi)		4500	4500	4500												
	28 Day Strength (psi)		5000	5000	5000												
	Design Camber @ Release (Plan-in.)		0.20	0.20	0.20												
	Design Camber @ Release (Modified-in.)		0.20	0.26	0.26												
	Absolute Difference in Camber @ Release (in.)		0.00	0.06	0.06												
BTB 40	Straight Strands			12	12	14											
	Deflected Strands			0	0	0											
	Distance Deflected Strands Raised (in.)			-	-	-											
	Release Strength (psi)			4500	4500	4500											
	28 Day Strength (psi)			5000	5000	5000											
	Design Camber @ Release (Plan-in.)			0.31	0.31	0.31											
	Design Camber @ Release (Modified-in.)			0.31	0.31	0.37											
	Absolute Difference in Camber @ Release (in.)			0.00	0.00	0.06											
BTB 45	Straight Strands				12	14	16	16									
	Deflected Strands				0	0	0	2									
	Distance Deflected Strands Raised (in.)				-	-	-	8									
	Release Strength (psi)				4500	4500	4500	4500									
	28 Day Strength (psi)				5000	5000	5000	5000									
	Design Camber @ Release (Plan-in.)				0.37	0.37	0.37	0.37									
	Design Camber @ Release (Modified-in.)				0.37	0.44	0.50	0.52									
	Absolute Difference in Camber @ Release (in.)				0.00	0.07	0.13	0.15									
BTB 50	Straight Strands					14	16	16	18								
	Deflected Strands					0	0	2	2								
	Distance Deflected Strands Raised (in.)					-	-	4	20								
	Release Strength (psi)					4500	4500	4500	4500								
	28 Day Strength (psi)					5000	5000	5000	5000								
	Design Camber @ Release (Plan-in.)					0.51	0.51	0.51	0.51								
	Design Camber @ Release (Modified-in.)					0.51	0.58	0.62	0.68								
	Absolute Difference in Camber @ Release (in.)					0.00	0.07	0.11	0.17								

* When combination pours are used for BTB95, BTB100, and BTB105, beam end debonding configuration shall be used at all beam ends.

		BTB 30	BTB 35	BTB 40	BTB 45	BTB 50	BTB 55	BTB 60	BTB 65	BTB 70	BTB 75	BTB 80	BTB 85	BTB 90	*BTB 95	*BTB 100	*BTB 105
	Straight Strands						16	16	18	20							
	Deflected Strands						0	2	2	4							
	Distance Deflected Strands Raised (in.)						-	0	14	22							
	Release Strength (psi)						4500	4500	4500	5000							
BTB 55	28 Day Strength (psi)						5000	5000	5000	5500							
	Design Camber @ Release (Plan-in.)						0.66	0.66	0.66	0.66							
	Design Camber @ Release (Modified-in.)						0.66	0.72	0.80	0.83							
	Absolute Difference in Camber @ Release (in.)						0.00	0.06	0.14	0.17							
	Straight Strands							16	18	20	22						
	Deflected Strands							2	2	4	6						
	Distance Deflected Strands Raised (in.)							0	12	12	18						
	Release Strength (psi)							4500	4500	5000	5500						
BTB 60	28 Day Strength (psi)							5000	5000	5500	6500						
	Design Camber @ Release (Plan-in.)							0.81	0.81	0.81	0.81						
	Design Camber @ Release (Modified-in.)							0.81	0.91	0.96	0.95						
	Absolute Difference in Camber @ Release (in.)							0.00	0.10	0.15	0.14						
	Straight Strands								18	20	22	24					
	Deflected Strands								2	4	6	8					
	Distance Deflected Strands Raised (in.)								0	10	14	16					
	Release Strength (psi)								4500	5000	5500	6000					
BTB 65	28 Day Strength (psi)								5000	5500	6500	7000					
	Design Camber @ Release (Plan-in.)								1.05	1.05	1.05	1.05					
	Design Camber @ Release (Modified-in.)								1.05	1.15	1.18	1.29					
	Absolute Difference in Camber @ Release (in.)								0.00	0.10	0.13	0.24					
	Straight Strands									20	22	24					
	Deflected Strands									4	6	8					
	Distance Deflected Strands Raised (in.)									0	4	6					
	Release Strength (psi)									5000	5500	6000					
BTB 70	28 Day Strength (psi)									5500	6500	7000					
	Design Camber @ Release (Plan-in.)									1.35	1.35	1.35					
	Design Camber @ Release (Modified-in.)									1.35	1.39	1.60					
	Absolute Difference in Camber @ Release (in.)									0.00	0.04	0.25					
	Straight Strands										22	24	28	30			
	Deflected Strands										6	8	8	8			
	Distance Deflected Strands Raised (in.)										0	2	10	14			
	Release Strength (psi)										5500	6000	6500	7500			
BTB 75	28 Day Strength (psi)										6500	7000	7500	8500			
	Design Camber @ Release (Plan-in.)										1.67	1.67	1.67	1.67			
	Design Camber @ Release (Modified-in.)										1.67	1.89	1.95	1.89			
	Absolute Difference in Camber @ Release (in.)										0.00	0.22	0.28	0.22			

* When combination pours are used for BTB95, BTB100, and BTB105, beam end debonding configuration shall be used at all beam ends.

		BTB 30	BTB 35	BTB 40	BTB 45	BTB 50	BTB 55	BTB 60	BTB 65	BTB 70	BTB 75	BTB 80	BTB 85	BTB 90	*BTB 95	*BTB 100	*BTB 105
BTB 80	Straight Strands											24	28	30	34		
	Deflected Strands											8	8	8	10		
	Distance Deflected Strands Raised (in.)											0	8	10	14		
	Release Strength (psi)											6000	6500	7500	8000		
	28 Day Strength (psi)											7000	7500	8500	9500		
	Design Camber @ Release (Plan-in.)											1.97	1.97	1.97	1.97		
	Design Camber @ Release (Modified-in.)											1.97	2.18	2.22	2.20		
	Absolute Difference in Camber @ Release (in.)											0.00	0.21	0.25	0.23		
BTB 85	Straight Strands												28	30	34		
	Deflected Strands												8	8	10		
	Distance Deflected Strands Raised (in.)												0	0	6		
	Release Strength (psi)												6500	7500	8000		
	28 Day Strength (psi)												7500	8500	9500		
	Design Camber @ Release (Plan-in.)												2.76	2.76	2.76		
	Design Camber @ Release (Modified-in.)												2.76	2.91	2.89		
	Absolute Difference in Camber @ Release (in.)												0.00	0.15	0.13		
BTB 90	Straight Strands													30	34	38	38
	Deflected Strands													8	10	8	12
	Distance Deflected Strands Raised (in.)													0	4	8	6
	Release Strength (psi)													7500	8000	8000	8500
	28 Day Strength (psi)													8500	9500	10000	10000
	Design Camber @ Release (Plan-in.)													3.07	3.07	3.07	3.07
	Design Camber @ Release (Modified-in.)													3.07	3.20	3.30	3.32
	Absolute Difference in Camber @ Release (in.)													0.00	0.13	0.23	0.25
BTB 95	Straight Strands														34	38	38
	Deflected Strands														10	8	12
	Distance Deflected Strands Raised (in.)														0	4	2
	Release Strength (psi)														8000	8000	8500
	28 Day Strength (psi)														9500	10000	10000
	Design Camber @ Release (Plan-in.)														3.68	3.68	3.68
	Design Camber @ Release (Modified-in.)														3.68	3.72	3.88
	Absolute Difference in Camber @ Release (in.)														0.00	0.04	0.20
BTB 100	Straight Strands															38	38
	Deflected Strands															8	12
	Distance Deflected Strands Raised (in.)															0	0
	Release Strength (psi)															8000	8500
	28 Day Strength (psi)															10000	10000
	Design Camber @ Release (Plan-in.)															4.17	4.17
	Design Camber @ Release (Modified-in.)															4.17	4.26
	Absolute Difference in Camber @ Release (in.)															0.00	0.09

* When combination pours are used for BTB95, BTB100, and BTB105, beam end debonding configuration shall be used at all beam ends.

		BTB 30	BTB 35	BTB 40	BTB 45	BTB 50	BTB 55	BTB 60	BTB 65	BTB 70	BTB 75	BTB 80	BTB 85	BTB 90	*BTB 95	*BTB 100	*BTB 105
BTB 105	Straight Strands																38
	Deflected Strands																12
	Distance Deflected Strands Raised (in.)																0
	Release Strength (psi)																8500
	28 Day Strength (psi)																10000
	Design Camber @ Release (Plan-in.)																4.42
	Design Camber @ Release (Modified-in.)																4.42
	Absolute Difference in Camber @ Release (in.)																0.00

* When combination pours are used for BTB95, BTB100, and BTB105, beam end debonding configuration shall be used at all beam ends.

		BTC 30	BTC 35	BTC 40	BTC 45	BTC 50	BTC 55	BTC 60	BTC 65	BTC 70	BTC 75	BTC 80	BTC 85	BTC 90	BTC 95	BTC 100	BTC 105	BTC 110	*BTC 115	*BTC 120
BTC 30	Straight Strands	8	8	10	10	12	14													
	Deflected Strands	0	0	0	0	0	0													
	Distance Deflected Strands Raised (in.)	-	-	-	-	-	-													
	Release Strength (psi)	4500	4500	4500	4500	4500	4500													
	28 Day Strength (psi)	5000	5000	5000	5000	5000	5000													
	Design Camber @ Release (Plan-in.)	0.09	0.09	0.09	0.09	0.09	0.09													
	Design Camber @ Release (Modified-in.)	0.09	0.09	0.11	0.11	0.14	0.16													
	Absolute Difference in Camber @ Release (in.)	0.00	0.00	0.02	0.02	0.05	0.07													
BTC 35	Straight Strands		8	10	10	12	14													
	Deflected Strands		0	0	0	0	0													
	Distance Deflected Strands Raised (in.)		-	-	-	-	-													
	Release Strength (psi)		4500	4500	4500	4500	4500													
	28 Day Strength (psi)		5000	5000	5000	5000	5000													
	Design Camber @ Release (Plan-in.)		0.11	0.11	0.11	0.11	0.11													
	Design Camber @ Release (Modified-in.)		0.11	0.15	0.15	0.18	0.21													
	Absolute Difference in Camber @ Release (in.)		0.00	0.04	0.04	0.07	0.10													
BTC 40	Straight Strands			10	10	12	14													
	Deflected Strands			0	0	0	0													
	Distance Deflected Strands Raised (in.)			-	-	-	-													
	Release Strength (psi)			4500	4500	4500	4500													
	28 Day Strength (psi)			5000	5000	5000	5000													
	Design Camber @ Release (Plan-in.)			0.18	0.18	0.18	0.18													
	Design Camber @ Release (Modified-in.)			0.18	0.18	0.23	0.27													
	Absolute Difference in Camber @ Release (in.)			0.00	0.00	0.05	0.09													
BTC 45	Straight Strands				10	12	14	14	14											
	Deflected Strands				0	0	0	0	2											
	Distance Deflected Strands Raised (in.)				-	-	-	-	0											
	Release Strength (psi)				4500	4500	4500	4500	5000											
	28 Day Strength (psi)				5000	5000	5000	5000	6000											
	Design Camber @ Release (Plan-in.)				0.21	0.21	0.21	0.21	0.21											
	Design Camber @ Release (Modified-in.)				0.21	0.27	0.32	0.32	0.33											
	Absolute Difference in Camber @ Release (in.)				0.00	0.06	0.11	0.11	0.12											
BTC 50	Straight Strands					12	14	14	14											
	Deflected Strands					0	0	0	2											
	Distance Deflected Strands Raised (in.)					-	-	-	0											
	Release Strength (psi)					4500	4500	4500	5000											
	28 Day Strength (psi)					5000	5000	5000	6000											
	Design Camber @ Release (Plan-in.)					0.31	0.31	0.31	0.31											
	Design Camber @ Release (Modified-in.)					0.31	0.37	0.37	0.39											
	Absolute Difference in Camber @ Release (in.)					0.00	0.06	0.06	0.08											

* When combination pours are used for the BTC115 and BTC120, the beam end debonding configuration shall be used at all beam ends.

		BTC 30	BTC 35	BTC 40	BTC 45	BTC 50	BTC 55	BTC 60	BTC 65	BTC 70	BTC 75	BTC 80	BTC 85	BTC 90	BTC 95	BTC 100	BTC 105	BTC 110	*BTC 115	*BTC 120
	Straight Strands						14	14	14	16										
	Deflected Strands						0	0	2	2										
	Distance Deflected Strands Raised (in.)						-	-	0	0										
	Release Strength (psi)						4500	4500	5000	5000										
BTC 55	28 Day Strength (psi)						5000	5000	6000	6000										
	Design Camber @ Release (Plan-in.)						0.42	0.42	0.42	0.42										
	Design Camber @ Release (Modified-in.)						0.42	0.42	0.44	0.51										
	Absolute Difference in Camber @ Release (in.)						0.00	0.00	0.02	0.09										
	Straight Strands							14	14	16	16									
	Deflected Strands							0	2	2	4									
	Distance Deflected Strands Raised (in.)							-	0	0	0									
	Release Strength (psi)							4500	5000	5000	5000									
BTC 60	28 Day Strength (psi)							5000	6000	6000	6000									
	Design Camber @ Release (Plan-in.)							0.46	0.46	0.46	0.46									
	Design Camber @ Release (Modified-in.)							0.46	0.49	0.56	0.64									
	Absolute Difference in Camber @ Release (in.)							0.00	0.03	0.10	0.18									
	Straight Strands								14	16	16	20								
	Deflected Strands								2	2	4	4								
	Distance Deflected Strands Raised (in.)								0	0	0	16								
	Release Strength (psi)								5000	5000	5000	6000								
BTC 65	28 Day Strength (psi)								6000	6000	6000	7000								
	Design Camber @ Release (Plan-in.)								0.54	0.54	0.54	0.54								
	Design Camber @ Release (Modified-in.)								0.54	0.62	0.70	0.80								
	Absolute Difference in Camber @ Release (in.)								0.00	0.08	0.16	0.26								
	Straight Strands									16	16	20	22							
	Deflected Strands									2	4	4	4							
	Distance Deflected Strands Raised (in.)									0	0	10	18							
	Release Strength (psi)									5000	5000	6000	6000							
BTC 70	28 Day Strength (psi)									6000	6000	7000	7000							
	Design Camber @ Release (Plan-in.)									0.67	0.67	0.67	0.67							
	Design Camber @ Release (Modified-in.)									0.67	0.76	0.93	0.97							
	Absolute Difference in Camber @ Release (in.)									0.00	0.09	0.26	0.30							
	Straight Strands										16	20	22	24						
	Deflected Strands										4	4	4	6						
	Distance Deflected Strands Raised (in.)										0	0	16	20						
	Release Strength (psi)										5000	6000	6000	6000						
BTC 75	28 Day Strength (psi)										6000	7000	7000	7000						
	Design Camber @ Release (Plan-in.)										0.83	0.83	0.83	0.83						
	Design Camber @ Release (Modified-in.)										0.83	1.13	1.06	1.09						
	Absolute Difference in Camber @ Release (in.)										0.00	0.30	0.23	0.26						

* When combination pours are used for the BTC115 and BTC120, the beam end debonding configuration shall be used at all beam ends.

		BTC 30	BTC 35	BTC 40	BTC 45	BTC 50	BTC 55	BTC 60	BTC 65	BTC 70	BTC 75	BTC 80	BTC 85	BTC 90	BTC 95	BTC 100	BTC 105	BTC 110	*BTC 115	*BTC 120
BTC 80	Straight Strands											20	22	24	28					
	Deflected Strands											4	4	6	6					
	Distance Deflected Strands Raised (in.)											0	0	10	24					
	Release Strength (psi)											6000	6000	6000	6500					
	28 Day Strength (psi)											7000	7000	7000	7500					
	Design Camber @ Release (Plan-in.)											1.11	1.11	1.11	1.11					
	Design Camber @ Release (Modified-in.)											1.11	1.36	1.38	1.37					
	Absolute Difference in Camber @ Release (in.)											0.00	0.25	0.27	0.26					
BTC 85	Straight Strands												22	24	28	30				
	Deflected Strands												4	6	6	6				
	Distance Deflected Strands Raised (in.)												0	8	20	24				
	Release Strength (psi)												6000	6000	6500	7000				
	28 Day Strength (psi)												7000	7000	7500	8000				
	Design Camber @ Release (Plan-in.)												1.31	1.31	1.31	1.31				
	Design Camber @ Release (Modified-in.)												1.31	1.50	1.55	1.58				
	Absolute Difference in Camber @ Release (in.)												0.00	0.19	0.24	0.27				
BTC 90	Straight Strands													24	28	30	34			
	Deflected Strands													6	6	6	8			
	Distance Deflected Strands Raised (in.)													0	10	14	20			
	Release Strength (psi)													6000	6500	7000	7500			
	28 Day Strength (psi)													7000	7500	8000	8500			
	Design Camber @ Release (Plan-in.)													1.65	1.65	1.65	1.65			
	Design Camber @ Release (Modified-in.)													1.65	1.90	1.94	1.95			
	Absolute Difference in Camber @ Release (in.)													0.00	0.25	0.29	0.30			
BTC 95	Straight Strands														28	30	34	38		
	Deflected Strands														6	6	8	8		
	Distance Deflected Strands Raised (in.)														0	0	10	16		
	Release Strength (psi)														6500	7000	7500	7500		
	28 Day Strength (psi)														7500	8000	8500	9000		
	Design Camber @ Release (Plan-in.)														2.29	2.29	2.29	2.29		
	Design Camber @ Release (Modified-in.)														2.29	2.45	2.44	2.53		
	Absolute Difference in Camber @ Release (in.)														0.00	0.16	0.15	0.24		
BTC 100	Straight Strands															30	34	38	40	44
	Deflected Strands															6	8	8	10	10
	Distance Deflected Strands Raised (in.)															0	4	12	14	20
	Release Strength (psi)															7000	7500	7500	7500	8000
	28 Day Strength (psi)															8000	8500	9000	9500	10000
	Design Camber @ Release (Plan-in.)															2.56	2.56	2.56	2.56	2.56
	Design Camber @ Release (Modified-in.)															2.56	2.81	2.81	2.81	2.77
	Absolute Difference in Camber @ Release (in.)															0.00	0.25	0.25	0.25	0.21

* When combination pours are used for the BTC115 and BTC120, the beam end debonding configuration shall be used at all beam ends.

		BTC 30	BTC 35	BTC 40	BTC 45	BTC 50	BTC 55	BTC 60	BTC 65	BTC 70	BTC 75	BTC 80	BTC 85	BTC 90	BTC 95	BTC 100	BTC 105	BTC 110	*BTC 115	*BTC 120
BTC 105	Straight Strands																34	38	40	44
	Deflected Strands																8	8	10	10
	Distance Deflected Strands Raised (in.)																0	4	8	12
	Release Strength (psi)																7500	7500	7500	8000
	28 Day Strength (psi)																8500	9000	9500	10000
	Design Camber @ Release (Plan-in.)																3.10	3.10	3.10	3.10
	Design Camber @ Release (Modified-in.)																3.10	3.30	3.27	3.34
	Absolute Difference in Camber @ Release (in.)																0.00	0.20	0.17	0.24
BTC 110	Straight Strands																	38	40	44
	Deflected Strands																	8	10	10
	Distance Deflected Strands Raised (in.)																	0	2	6
	Release Strength (psi)																	7500	7500	8000
	28 Day Strength (psi)																	9000	9500	10000
	Design Camber @ Release (Plan-in.)																	3.62	3.62	3.62
	Design Camber @ Release (Modified-in.)																	3.62	3.77	3.84
	Absolute Difference in Camber @ Release (in.)																	0.00	0.15	0.22
BTC 115	Straight Strands																		40	44
	Deflected Strands																		10	10
	Distance Deflected Strands Raised (in.)																		0	2
	Release Strength (psi)																		7500	8000
	28 Day Strength (psi)																		9500	10000
	Design Camber @ Release (Plan-in.)																		4.04	4.04
	Design Camber @ Release (Modified-in.)																		4.04	4.22
	Absolute Difference in Camber @ Release (in.)																		0.00	0.18
BTC 120	Straight Strands																			44
	Deflected Strands																			10
	Distance Deflected Strands Raised (in.)																			0
	Release Strength (psi)																			8000
	28 Day Strength (psi)																			10000
	Design Camber @ Release (Plan-in.)																			4.48
	Design Camber @ Release (Modified-in.)																			4.48
	Absolute Difference in Camber @ Release (in.)																			0.00

* When combination pours are used for the BTC115 and BTC120, the beam end debonding configuration shall be used at all beam ends.

		BTD 50	BTD 55	BTD 60	BTD 65	BTD 70	BTD 75	BTD 80	BTD 85	BTD 90	BTD 95	BTD 100	BTD 105	BTD 110	BTD 115	BTD 120	BTD 125	*BTD 130	*BTD 135
BTD 50	Straight Strands	12	14	12	14														
	Deflected Strands	0	0	2	2														
	Distance Deflected Strands Raised (in.)	-	-	0	0														
	Release Strength (psi)	4500	4500	4500	4500														
	28 Day Strength (psi)	5000	5000	5000	5000														
	Design Camber @ Release (Plan-in.)	0.24	0.24	0.24	0.24														
	Design Camber @ Release (Modified-in.)	0.24	0.30	0.28	0.32														
	Absolute Difference in Camber @ Release (in.)	0.00	0.06	0.04	0.08														
BTD 55	Straight Strands		14	12	14	14													
	Deflected Strands		0	2	2	2													
	Distance Deflected Strands Raised (in.)		-	0	0	0													
	Release Strength (psi)		4500	4500	4500	4500													
	28 Day Strength (psi)		5000	5000	5000	5000													
	Design Camber @ Release (Plan-in.)		0.34	0.34	0.34	0.34													
	Design Camber @ Release (Modified-in.)		0.34	0.32	0.37	0.37													
	Absolute Difference in Camber @ Release (in.)		0.00	0.02	0.03	0.03													
BTD 60	Straight Strands			12	14	14	16												
	Deflected Strands			2	2	2	2												
	Distance Deflected Strands Raised (in.)			0	0	0	0												
	Release Strength (psi)			4500	4500	4500	5000												
	28 Day Strength (psi)			5000	5000	5000	6000												
	Design Camber @ Release (Plan-in.)			0.36	0.36	0.36	0.36												
	Design Camber @ Release (Modified-in.)			0.36	0.42	0.42	0.47												
	Absolute Difference in Camber @ Release (in.)			0.00	0.06	0.06	0.11												
BTD 65	Straight Strands				14	14	16	18											
	Deflected Strands				2	2	2	2											
	Distance Deflected Strands Raised (in.)				0	0	0	4											
	Release Strength (psi)				4500	4500	5000	5000											
	28 Day Strength (psi)				5000	5000	6000	6000											
	Design Camber @ Release (Plan-in.)				0.47	0.47	0.47	0.47											
	Design Camber @ Release (Modified-in.)				0.47	0.47	0.52	0.60											
	Absolute Difference in Camber @ Release (in.)				0.00	0.00	0.05	0.13											
BTD 70	Straight Strands					14	16	18	18										
	Deflected Strands					2	2	2	4										
	Distance Deflected Strands Raised (in.)					0	0	4	6										
	Release Strength (psi)					4500	5000	5000	5000										
	28 Day Strength (psi)					5000	6000	6000	6000										
	Design Camber @ Release (Plan-in.)					0.49	0.49	0.49	0.49										
	Design Camber @ Release (Modified-in.)					0.49	0.57	0.66	0.68										
	Absolute Difference in Camber @ Release (in.)					0.00	0.08	0.17	0.19										

* When combination pours are used for BTD130 and BTD135, the beam end debonding configuration shall be used at all beam ends.

		BTD 50	BTD 55	BTD 60	BTD 65	BTD 70	BTD 75	BTD 80	BTD 85	BTD 90	BTD 95	BTD 100	BTD 105	BTD 110	BTD 115	BTD 120	BTD 125	*BTD 130	*BTD 135
BTD 75	Straight Strands						16	18	18	20									
	Deflected Strands						2	2	4	4									
	Distance Deflected Strands Raised (in.)						0	0	4	4									
	Release Strength (psi)						5000	5000	5000	5500									
	28 Day Strength (psi)						6000	6000	6000	6500									
	Design Camber @ Release (Plan-in.)						0.62	0.62	0.62	0.62									
	Design Camber @ Release (Modified-in.)						0.62	0.72	0.75	0.82									
	Absolute Difference in Camber @ Release (in.)						0.00	0.10	0.13	0.20									
BTD 80	Straight Strands							18	18	20	24								
	Deflected Strands							2	4	4	4								
	Distance Deflected Strands Raised (in.)							0	0	0	8								
	Release Strength (psi)							5000	5000	5500	5500								
	28 Day Strength (psi)							6000	6000	6500	6500								
	Design Camber @ Release (Plan-in.)							0.78	0.78	0.78	0.78								
	Design Camber @ Release (Modified-in.)							0.78	0.83	0.91	1.07								
	Absolute Difference in Camber @ Release (in.)							0.00	0.05	0.13	0.29								
BTD 85	Straight Strands								18	20	24								
	Deflected Strands								4	4	4								
	Distance Deflected Strands Raised (in.)								0	0	4								
	Release Strength (psi)								5000	5500	5500								
	28 Day Strength (psi)								6000	6500	6500								
	Design Camber @ Release (Plan-in.)								0.90	0.90	0.90								
	Design Camber @ Release (Modified-in.)								0.90	0.96	1.18								
	Absolute Difference in Camber @ Release (in.)								0.00	0.06	0.28								
BTD 90	Straight Strands									20	24	26							
	Deflected Strands									4	4	4							
	Distance Deflected Strands Raised (in.)									0	0	22							
	Release Strength (psi)									5500	5500	6000							
	28 Day Strength (psi)									6500	6500	7000							
	Design Camber @ Release (Plan-in.)									1.03	1.03	1.03							
	Design Camber @ Release (Modified-in.)									1.03	1.28	1.32							
	Absolute Difference in Camber @ Release (in.)									0.00	0.25	0.29							
BTD 95	Straight Strands										24	26	28						
	Deflected Strands										4	4	6						
	Distance Deflected Strands Raised (in.)										0	0	12						
	Release Strength (psi)										5500	6000	6000						
	28 Day Strength (psi)										6500	7000	7000						
	Design Camber @ Release (Plan-in.)										1.38	1.38	1.38						
	Design Camber @ Release (Modified-in.)										1.38	1.65	1.66						
	Absolute Difference in Camber @ Release (in.)										0.00	0.27	0.28						

* When combination pours are used for BTD130 and BTD135, the beam end debonding configuration shall be used at all beam ends.

		BTD 50	BTD 55	BTD 60	BTD 65	BTD 70	BTD 75	BTD 80	BTD 85	BTD 90	BTD 95	BTD 100	BTD 105	BTD 110	BTD 115	BTD 120	BTD 125	*BTD 130	*BTD 135
	Straight Strands											26	28	30	34				
	Deflected Strands											4	6	6	6				
	Distance Deflected Strands Raised (in.)											0	6	14	28				
	Release Strength (psi)											6000	6000	6500	7000				
BTD 100	28 Day Strength (psi)											7000	7000	7500	8000				
	Design Camber @ Release (Plan-in.)											1.57	1.57	1.57	1.57				
	Design Camber @ Release (Modified-in.)											1.57	1.85	1.87	1.85				
	Absolute Difference in Camber @ Release (in.)											0.00	0.28	0.30	0.28				
	Straight Strands												28	30	34				
	Deflected Strands												6	6	6				
	Distance Deflected Strands Raised (in.)												0	4	18				
	Release Strength (psi)												6000	6500	7000				
BTD 105	28 Day Strength (psi)												7000	7500	8000				
	Design Camber @ Release (Plan-in.)												1.89	1.89	1.89				
	Design Camber @ Release (Modified-in.)												1.89	2.17	2.15				
	Absolute Difference in Camber @ Release (in.)												0.00	0.28	0.26				
	Straight Strands													30	34	36	38		
	Deflected Strands													6	6	8	10		
	Distance Deflected Strands Raised (in.)													0	2	10	14		
	Release Strength (psi)													6500	7000	7000	7500		
BTD 110	28 Day Strength (psi)													7500	8000	8000	8500		
	Design Camber @ Release (Plan-in.)													2.34	2.34	2.34	2.34		
	Design Camber @ Release (Modified-in.)													2.34	2.62	2.62	2.57		
	Absolute Difference in Camber @ Release (in.)													0.00	0.28	0.28	0.23		
	Straight Strands														34	36	38	42	46
	Deflected Strands														6	8	10	12	12
	Distance Deflected Strands Raised (in.)														0	2	6	14	18
	Release Strength (psi)														7000	7000	7500	7500	8000
BTD 115	28 Day Strength (psi)														8000	8000	8500	9000	9500
	Design Camber @ Release (Plan-in.)														2.75	2.75	2.75	2.75	2.75
	Design Camber @ Release (Modified-in.)														2.75	2.99	3.00	2.95	3.01
	Absolute Difference in Camber @ Release (in.)														0.00	0.24	0.25	0.20	0.26
	Straight Strands															36	38	42	46
	Deflected Strands															8	10	12	12
	Distance Deflected Strands Raised (in.)															0	2	8	14
	Release Strength (psi)															7000	7500	7500	8000
BTD 120	28 Day Strength (psi)															8000	8500	9000	9500
	Design Camber @ Release (Plan-in.)															3.14	3.14	3.14	3.14
	Design Camber @ Release (Modified-in.)															3.14	3.28	3.38	3.33
	Absolute Difference in Camber @ Release (in.)															0.00	0.14	0.24	0.19

* When combination pours are used for BTD130 and BTD135, the beam end debonding configuration shall be used at all beam ends.

		BTD 50	BTD 55	BTD 60	BTD 65	BTD 70	BTD 75	BTD 80	BTD 85	BTD 90	BTD 95	BTD 100	BTD 105	BTD 110	BTD 115	BTD 120	BTD 125	*BTD 130	*BTD 135
	Straight Strands																38	42	46
	Deflected Strands																10	12	12
	Distance Deflected Strands Raised (in.)																0	4	10
	Release Strength (psi)																7500	7500	8000
BTD 125	28 Day Strength (psi)																8500	9000	9500
	Design Camber @ Release (Plan-in.)																3.46	3.46	3.46
	Design Camber @ Release (Modified-in.)																3.46	3.70	3.65
	Absolute Difference in Camber @ Release (in.)																0.00	0.24	0.19
	Straight Strands																	42	46
	Deflected Strands																	12	12
	Distance Deflected Strands Raised (in.)																	0	2
	Release Strength (psi)																	7500	8000
BTD 130	28 Day Strength (psi)																	9000	9500
	Design Camber @ Release (Plan-in.)																	4.04	4.04
	Design Camber @ Release (Modified-in.)																	4.04	4.24
	Absolute Difference in Camber @ Release (in.)																	0.00	0.20
	Straight Strands																		46
	Deflected Strands																		12
	Distance Deflected Strands Raised (in.)																		0
	Release Strength (psi)																		8000
BTD 135	28 Day Strength (psi)																		9500
	Design Camber @ Release (Plan-in.)																		4.46
	Design Camber @ Release (Modified-in.)																		4.46
	Absolute Difference in Camber @ Release (in.)																		0.00

* When combination pours are used for BTD130 and BTD135, the beam end debonding configuration shall be used at all beam ends.

		BTE 60	BTE 65	BTE 70	BTE 75	BTE 80	BTE 85	BTE 90	BTE 95	BTE 100	BTE 105	BTE 110	BTE 115	BTE 120	BTE 125	BTE 130	BTE 135	BTE 140	BTE 145	*BTE 150	*BTE 155
BTE 60	Straight Strands	14	14	16	16	18	18														
	Deflected Strands	0	0	0	0	0	2														
	Distance Deflected Strands Raised (in.)	-	-	-	-	-	0														
	Release Strength (psi)	4500	4500	4500	4500	5000	5000														
	28 Day Strength (psi)	5000	5000	5000	5000	6000	6000														
	Design Camber @ Release (Plan-in.)	0.33	0.33	0.33	0.33	0.33	0.33														
	Design Camber @ Release (Modified-in.)	0.33	0.33	0.38	0.38	0.43	0.46														
	Absolute Difference in Camber @ Release (in.)	0.00	0.00	0.05	0.05	0.10	0.13														
BTE 65	Straight Strands		14	16	16	18	18														
	Deflected Strands		0	0	0	0	2														
	Distance Deflected Strands Raised (in.)		-	-	-	-	0														
	Release Strength (psi)		4500	4500	4500	5000	5000														
	28 Day Strength (psi)		5000	5000	5000	6000	6000														
	Design Camber @ Release (Plan-in.)		0.36	0.36	0.36	0.36	0.36														
	Design Camber @ Release (Modified-in.)		0.36	0.42	0.42	0.48	0.52														
	Absolute Difference in Camber @ Release (in.)		0.00	0.06	0.06	0.12	0.16														
BTE 70	Straight Strands			16	16	18	18														
	Deflected Strands			0	0	0	2														
	Distance Deflected Strands Raised (in.)			-	-	-	0														
	Release Strength (psi)			4500	4500	5000	5000														
	28 Day Strength (psi)			5000	5000	6000	6000														
	Design Camber @ Release (Plan-in.)			0.46	0.46	0.46	0.46														
	Design Camber @ Release (Modified-in.)			0.46	0.46	0.53	0.57														
	Absolute Difference in Camber @ Release (in.)			0.00	0.00	0.07	0.11														
BTE 75	Straight Strands				16	18	18	18													
	Deflected Strands				0	0	2	2													
	Distance Deflected Strands Raised (in.)				-	-	0	0													
	Release Strength (psi)				4500	5000	5000	5000													
	28 Day Strength (psi)				5000	6000	6000	6000													
	Design Camber @ Release (Plan-in.)				0.49	0.49	0.49	0.49													
	Design Camber @ Release (Modified-in.)				0.49	0.57	0.62	0.62													
	Absolute Difference in Camber @ Release (in.)				0.00	0.08	0.13	0.13													
BTE 80	Straight Strands					18	18	18	20	22											
	Deflected Strands					0	2	2	4	4											
	Distance Deflected Strands Raised (in.)					-	0	0	4	8											
	Release Strength (psi)					5000	5000	5000	5000	5000											
	28 Day Strength (psi)					6000	6000	6000	6000	6000											
	Design Camber @ Release (Plan-in.)					0.61	0.61	0.61	0.61	0.61											
	Design Camber @ Release (Modified-in.)					0.61	0.66	0.66	0.77	0.84											
	Absolute Difference in Camber @ Release (in.)					0.00	0.05	0.05	0.16	0.23											

* When combination pours are used for BTE150 and BTE155, the beam end debonding configuration shall be used at all beam ends.

		BTE 60	BTE 65	BTE 70	BTE 75	BTE 80	BTE 85	BTE 90	BTE 95	BTE 100	BTE 105	BTE 110	BTE 115	BTE 120	BTE 125	BTE 130	BTE 135	BTE 140	BTE 145	*BTE 150	*BTE 155
BTE 85	Straight Strands						18	18	20	22											
	Deflected Strands						2	2	4	4											
	Distance Deflected Strands Raised (in.)						0	0	0	6											
	Release Strength (psi)						5000	5000	5000	5000											
	28 Day Strength (psi)						6000	6000	6000	6000											
	Design Camber @ Release (Plan-in.)						0.71	0.71	0.71	0.71											
	Design Camber @ Release (Modified-in.)						0.71	0.71	0.85	0.91											
	Absolute Difference in Camber @ Release (in.)						0.00	0.00	0.14	0.20											
BTE 90	Straight Strands							18	20	22											
	Deflected Strands							2	4	4											
	Distance Deflected Strands Raised (in.)							0	0	4											
	Release Strength (psi)							5000	5000	5000											
	28 Day Strength (psi)							6000	6000	6000											
	Design Camber @ Release (Plan-in.)							0.73	0.73	0.73											
	Design Camber @ Release (Modified-in.)							0.73	0.89	0.97											
	Absolute Difference in Camber @ Release (in.)							0.00	0.16	0.24											
BTE 95	Straight Strands								20	22	24										
	Deflected Strands								4	4	4										
	Distance Deflected Strands Raised (in.)								0	0	0										
	Release Strength (psi)								5000	5000	5000										
	28 Day Strength (psi)								6000	6000	6000										
	Design Camber @ Release (Plan-in.)								0.96	0.96	0.96										
	Design Camber @ Release (Modified-in.)								0.96	1.04	1.19										
	Absolute Difference in Camber @ Release (in.)								0.00	0.08	0.23										
BTE 100	Straight Strands									22	24										
	Deflected Strands									4	4										
	Distance Deflected Strands Raised (in.)									0	0										
	Release Strength (psi)									5000	5000										
	28 Day Strength (psi)									6000	6000										
	Design Camber @ Release (Plan-in.)									1.11	1.11										
	Design Camber @ Release (Modified-in.)									1.11	1.24										
	Absolute Difference in Camber @ Release (in.)									0.00	0.13										
BTE 105	Straight Strands										24	26	28	30							
	Deflected Strands										4	6	6	8							
	Distance Deflected Strands Raised (in.)										0	0	4	12							
	Release Strength (psi)										5000	5000	5500	5500							
	28 Day Strength (psi)										6000	6000	6000	6000							
	Design Camber @ Release (Plan-in.)										1.31	1.31	1.31	1.31							
	Design Camber @ Release (Modified-in.)										1.31	1.51	1.57	1.58							
	Absolute Difference in Camber @ Release (in.)										0.00	0.20	0.26	0.27							

* When combination pours are used for BTE150 and BTE155, the beam end debonding configuration shall be used at all beam ends.

		BTE 60	BTE 65	BTE 70	BTE 75	BTE 80	BTE 85	BTE 90	BTE 95	BTE 100	BTE 105	BTE 110	BTE 115	BTE 120	BTE 125	BTE 130	BTE 135	BTE 140	BTE 145	*BTE 150	*BTE 155
	Straight Strands											26	28	30	32						
	Deflected Strands											6	6	8	8						
	Distance Deflected Strands Raised (in.)											0	0	4	16						
	Release Strength (psi)											5000	5500	5500	6500						
BTE 110	28 Day Strength (psi)											6000	6000	6000	7500						
	Design Camber @ Release (Plan-in.)											1.61	1.61	1.61	1.61						
	Design Camber @ Release (Modified-in.)											1.61	1.68	1.80	1.90						
	Absolute Difference in Camber @ Release (in.)											0.00	0.07	0.19	0.29						
	Straight Strands												28	30	32						
	Deflected Strands												6	8	8						
	Distance Deflected Strands Raised (in.)												0	0	12						
	Release Strength (psi)												5500	5500	6500						
BTE 115	28 Day Strength (psi)												6000	6000	7500						
	Design Camber @ Release (Plan-in.)												1.78	1.78	1.78						
	Design Camber @ Release (Modified-in.)												1.78	1.94	2.06						
	Absolute Difference in Camber @ Release (in.)												0.00	0.16	0.28						
	Straight Strands													30	32	36	40				
	Deflected Strands													8	8	8	8				
	Distance Deflected Strands Raised (in.)													0	4	14	28				
	Release Strength (psi)													5500	6500	6500	7000				
BTE 120	28 Day Strength (psi)													6000	7500	7500	8000				
	Design Camber @ Release (Plan-in.)													2.07	2.07	2.07	2.07				
	Design Camber @ Release (Modified-in.)													2.07	2.32	2.37	2.33				
	Absolute Difference in Camber @ Release (in.)													0.00	0.25	0.30	0.26				
	Straight Strands														32	36	40	42			
	Deflected Strands														8	8	8	10			
	Distance Deflected Strands Raised (in.)														0	4	16	18			
	Release Strength (psi)														6500	6500	7000	7500			
BTE 125	28 Day Strength (psi)														7500	7500	8000	8500			
	Design Camber @ Release (Plan-in.)														2.48	2.48	2.48	2.48			
	Design Camber @ Release (Modified-in.)														2.48	2.77	2.73	2.76			
	Absolute Difference in Camber @ Release (in.)														0.00	0.29	0.25	0.28			
	Straight Strands															36	40	42			
	Deflected Strands															8	8	10			
	Distance Deflected Strands Raised (in.)															0	2	8			
	Release Strength (psi)															6500	7000	7500			
BTE 130	28 Day Strength (psi)															7500	8000	8500			
	Design Camber @ Release (Plan-in.)															2.95	2.95	2.95			
	Design Camber @ Release (Modified-in.)															2.95	3.22	3.20			
	Absolute Difference in Camber @ Release (in.)															0.00	0.27	0.25			

* When combination pours are used for BTE150 and BTE155, the beam end debonding configuration shall be used at all beam ends.

		BTE 60	BTE 65	BTE 70	BTE 75	BTE 80	BTE 85	BTE 90	BTE 95	BTE 100	BTE 105	BTE 110	BTE 115	BTE 120	BTE 125	BTE 130	BTE 135	BTE 140	BTE 145	*BTE 150	*BTE 155
	Straight Strands																40	42	44	48	
	Deflected Strands																8	10	12	12	
	Distance Deflected Strands Raised (in.)																0	0	6	14	
	Release Strength (psi)																7000	7500	7500	7500	
BTE 135	28 Day Strength (psi)																8000	8500	9000	9500	
	Design Camber @ Release (Plan-in.)																3.34	3.34	3.34	3.34	
	Design Camber @ Release (Modified-in.)																3.34	3.59	3.59	3.56	
	Absolute Difference in Camber @ Release (in.)																0.00	0.25	0.25	0.22	
	Straight Strands																	42	44	48	50
	Deflected Strands																	10	12	12	12
	Distance Deflected Strands Raised (in.)																	0	2	8	10
	Release Strength (psi)																	7500	7500	7500	8000
BTE 140	28 Day Strength (psi)																	8500	9000	9500	10500
	Design Camber @ Release (Plan-in.)																	3.65	3.65	3.65	3.65
	Design Camber @ Release (Modified-in.)																	3.65	3.86	3.93	3.94
	Absolute Difference in Camber @ Release (in.)																	0.00	0.21	0.28	0.29
	Straight Strands																		44	48	50
	Deflected Strands																		12	12	12
	Distance Deflected Strands Raised (in.)																		0	4	6
	Release Strength (psi)																		7500	7500	8000
BTE 145	28 Day Strength (psi)																		9000	9500	10500
	Design Camber @ Release (Plan-in.)																		4.02	4.02	4.02
	Design Camber @ Release (Modified-in.)																		4.02	4.21	4.21
	Absolute Difference in Camber @ Release (in.)																		0.00	0.19	0.19
	Straight Strands																			48	50
	Deflected Strands																			12	12
	Distance Deflected Strands Raised (in.)																			0	0
	Release Strength (psi)																			7500	8000
BTE 150	28 Day Strength (psi)																			9500	10500
	Design Camber @ Release (Plan-in.)																			4.48	4.48
	Design Camber @ Release (Modified-in.)																			4.48	4.60
	Absolute Difference in Camber @ Release (in.)																			0.00	0.12
	Straight Strands																				50
	Deflected Strands																				12
	Distance Deflected Strands Raised (in.)																				0
	Release Strength (psi)																				8000
BTE 155	28 Day Strength (psi)																				10500
	Design Camber @ Release (Plan-in.)																				4.64
	Design Camber @ Release (Modified-in.)																				4.64
	Absolute Difference in Camber @ Release (in.)																				0.00

* When combination pours are used for BTE150 and BTE155, the beam end debonding configuration shall be used at all beam ends.

PROCEDURE FOR CASTING DIFFERENT LENGTH PRECAST/PRESTRESS CONCRETE BRIDGE UNITS (Combined Beam Pours)

SCOPE:
To establish procedures for the fabrication of beams with different lengths on one casting bed set-up. Any deviation from the beam design standard for casting different size or different length prestressed concrete bridge beams will require prior approval. Apply this IM appendix to LX beams only.

This procedure allows, for example, the casting of an LXD60 with an LXD65 strand pattern, and LXD90 with an LXD95 strand pattern, etc. This procedure is acceptable with the following restrictions:

A. LXA46, LXB59, and LXC67 cannot be cast with the next longer beam because the strand patterns are not compatible due to the change in beam web width.

B. The following beams, if cast with the next longer beam, will require the minimum release strength and the 28-day strength as follows:

BEAM	RELEASE STRENGTH Min, F'c, psi	28-DAY STRENGTH Min, F'c, psi
LXA50	5000	5200
LXB63	5000	5200
LXC75	5100	5200
LXD95	5200	6500
LXD100	5500	6500

Use of the next longer beam strand pattern may result in camber increase in the modified beams. For example, the calculated camber at the time of erection for an LXD90 beam (with LXD95 strand pattern) will increase by approximately 0.6 inch. Whenever such beam modifications are used, the fabricators shall notify the District Materials Engineer prior to fabrication.

C. Alternate Strand Pattern - The alternate strand pattern option will require the fabricator to comply with the following requirements:

Contractor will forward the proposed request to the project engineer with the following:

a. Fabricator’s request for the alternate strand pattern change

b. Fabricator’s calculations

c. Consultant’s independent calculations (signed, stamped and approved)

d. Contractor's written letter of concurrence and acknowledgement for the responsibility of any construction changes and any additional costs that may result from the beam modifications

NOTE: If contractor does not concur with the proposed strand pattern change and the beam modification and does not assume responsibility for any construction changes or the possibility of any additional cost then the request will not be accepted.

The Project Engineer will forward the completed documents (signed and approved by the contractor) to the District Materials Engineer.

The District Materials Engineer will forward copies of the contractor's written approval, fabricator's calculations and the independent consultant's calculations to the Office of Bridges and Structures for review and approval.

The proposed beam modifications shall be approved prior to the start of fabrication process. It's expected that all producers will follow these guidelines.

Only original documents will be accepted (No fax or photocopies).

PRINCIPAL FACTORS IN QUALITY CONTROL

Apply this IM appendix for both LRFD and LX beams.

1. Management Commitment to Quality

    a. All producers shall develop a statement describing their commitment to quality.

2. Safety-Management Commitment to Safety

    a. Safety Policy

    b. Safety Program

    c. Designated Safety Officer

    d. Compliance with applicable laws, rules, regulations and ordinances governing safety.

3. Qualified personnel for all stages of fabrication (See requirements of Section 2407.01.)

    a. Maintain a list of plant personnel skilled and experienced for each fabrication process and the minimum number of skilled and experienced personnel needed for each process. (superintendents, lead workers & foremen)

    b. Identify personnel who prepare shop and/or production drawings.

    c. Maintain a list of personnel who are trained, certified and are responsible for QC inspection.

    d. Maintain a list of specially trained and authorized personnel to do tension and detentioning.

4. Testing and inspection of the various materials selected for use

    a. Identify all materials sources.

    b. Procedures used to assure that only approved materials will be incorporated into the work

    c. Storage methods and stockpiling of various materials

5. Clear & complete shop drawings

    a. Procedures for developing and distributing shop and production drawings

    b. Procedures for submittal of drawings for approval by the Design Engineer and/or the Consulting Engineer.

6. Accurate stressing procedures

    a. Calculation procedures

    b. A prescribed stressing procedure repeated every time the bed is used
    c. Description of tensioning equipment and stressing beds
    d. Checking for line and grade

7. Control of dimensions and tolerances
    a. Form condition assessment procedures
    b. Strand placement accuracy methods
    c. Form alignment procedure methods
    d. Overall dimensional accuracy methods

8. Positioning of all embedded items
    a. Procedures for accurate placement of reinforcing steel, sole plates and inserts, etc.

9. Proportioning and adequate mixing of concrete
    a. List of all approved mix designs & applications
    b. Description of mixing units, including manufacturer's recommended capacity
    c. Procedures for producing concrete of uniform quality batch after batch
    d. Description of maintenance and up-keep procedures

10. Handling, placing and consolidation of concrete
    a. Description of consolidation method (number and type of vibrators, consolidation zones)
    b. Number of lifts during placement and placement procedures
    c. Cold and hot weather concrete placement procedures
    d. Timeliness of placement
    e. Delivery (hauling and handling) methods
    f. Finishing methods
    g. Procedures to avoid cold joints in concrete placement

11. Curing

a. Procedures and equipment used to cure the concrete

b. Procedures used when artificial heat is used in curing

c. Equipment used to monitor curing temperatures

d. Corrective action (methods & procedures)

e. Form removal

12. Accurate detentioning procedure

a. Single strand detentioning procedure (if used)

b. Multiple strand detentioning procedure (if used)

c. Draped strands detentioning procedure (if used)

13. Final finish, storing and transporting units

a. Procedure for preparing and finishing facia girders

b. Final finishing procedures

c. Maintenance and upkeep of dunnage

d. Overhang, tie down and protection procedures

e. Notification for final inspection and approval

14. Record keeping

a. Timeliness of documentation

b. Samples of records kept

c. Samples of forms used

d. Availability of records and documentations

15. Problem resolution procedures

16. Repair procedure

a. Minor repair

b. Structural repair

GLOSSARY OF TERMS

This IM applies to both LRFD and LX beams.

Abutment: A stationary anchorage system that is independent of the bed or casting mold, used to withstand tensioning loads. The structure against which the tendons are stressed and anchored.

Admixture: A material used as an ingredient in concrete to enhance special characteristics.

Ambient Temperature: The temperature of the air surrounding the form into which concrete is to be cast.

Anchorage: In pretensioned concrete, a device used to anchor the tendon to the abutment during hardening of the concrete.

Bleeding: the migration of mix water to the surface of freshly placed concrete.

Blocking (Dunnage): Supports on which a precast member is stored. Usually wood, but can be concrete, steel or other material.

Bug Holes (Voids or Air Pockets): Small holes on formed concrete surfaces caused by air or water bubbles. (In some cases may be caused by improper vibration during concrete placement.)

Bulkheads (Headers): The end form of a prestressed member.

Camber: The vertical arch in a concrete unit caused by the force generated when the stress from the tensioned tendons is transferred into the concrete. Positive camber is vertical deviation above the longitudinal axis of the product and negative camber is below the axis.

Confining Reinforcement: Reinforcement, which surrounds areas of potential stress concentrations to distribute the forces and control cracking.

Crack: A visible separation of the concrete at the surface (see hairline crack).

Creep: Time-dependent length change caused by stress. In prestressed concrete, the shortening of a member over time caused by the compressive stresses.

Curing: The control of humidity and temperature of freshly placed concrete until the concrete attains the strength specified before stress transfer. 'Accelerated' curing indicates the use of an artificial means, usually steam, to hasten the process by including higher temperatures during the curing period than would normally be achieved by natural cure.

Curing Membrane: Materials applied to concrete surface to prevent the moisture in concrete from evaporating too rapidly.

Debond (Masking): Any method used to prevent the concrete from bonding to the reinforcement (usually strand). Placing a sheath around the strand to prevent bond.

Degradation: In aggregates, the breakdown of the particles caused by abrasive or weathering forces.

Efflorescence: A white crystalline or powdery deposit on the surface of the concrete. Results from leaching of lime or calcium hydroxide out of a permeable concrete mass over time by water followed by a reaction with carbon dioxide or acidic pollutants.

Elongation: Extension of strand under given load based on its physical characteristics.

Form Release Agent: A substance applied to the forms for preventing bond between the forms and the concrete cast in it.

Gross Theoretical Elongation: The calculated elongation from chuck to chuck which includes all necessary corrections for operational losses (seating, thermal, slippage, etc.)

Hairline Crack: Very fine cracks visible to the naked eye. Causes due to drying shrinkage and thermal expansion.

Honeycomb: Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse-aggregate particles.

Laitance: A thin, weak, brittle layer of cement and aggregate fines that float on a concrete surface4 caused by excess water used in the mix. Laitance can create an eggshell surface over hidden voids.

Load Cell: Sensitive electrically operated strain gauges attached to a calibrated Load Cell to provide direct readings of compressive loads applied to the Load Cell.

Net Theoretical Elongation: The calculated elongation from chuck to chuck after seating including all appropriate and necessary corrections (slippage, thermal, seating, etc.)(which is elongation minus live end seating).

Release Strength (Transfer Strength): The compressive strength of the concrete when detensioning occurs.

Segregation: The tendency of the coarse particles to separate from the finer particles, in concrete, the coarse aggregate and drier material remains behind, while the mortar and wetter material flows ahead; this also occurs in a vertical direction when wet concrete is over vibrated or dropped vertically into the forms, the mortar and wetter materials rising to the top.

Shrinkage: The shortening of concrete units due to drying.

Spall: A fragment of concrete broken away from the concrete unit.

Strain: Deformation (elongation) of the strand due to the applied force, usually measured in inches/inch.

Strand: A seven-wire stress-relieved or low-relaxation tendon (cable) produced in accordance with specified standards for pretensioning operations.

Strand Chuck: A device for holding a strand under tension, generally comprised of a barrel, grooved jaws, with an “O” ring pulling them together and a spring equipped cap.
Strand Relaxation: The loss of stress in the prestressed steel strand occurring over a period of time while the strand is under stress due to the realignment of the steel properties.

Stress: The applied force (pressure) that tends to cause deformation (elongation in the strand).

Superplasticizer: A high range water-reducing admixture (HRWR) used to produce a higher concrete slump with out additional water, or maintaining slump while reducing the amount of water.

Surface Defects: Defects that appear on the surface of concrete during concrete pours or shortly after completion and are usually caused by poor quality materials, improper mix design, lack of placing and curing procedures, or poor workmanship (honeycomb, air voids, laitance, stains, cracks, small holes, large holes, etc.)

Sweep: Deviation from a straight line parallel to the centerline of the beam (horizontal alignment).

Web: The narrow portion of the cross section of a beam.

Apply this IM appendix for LX beams only.

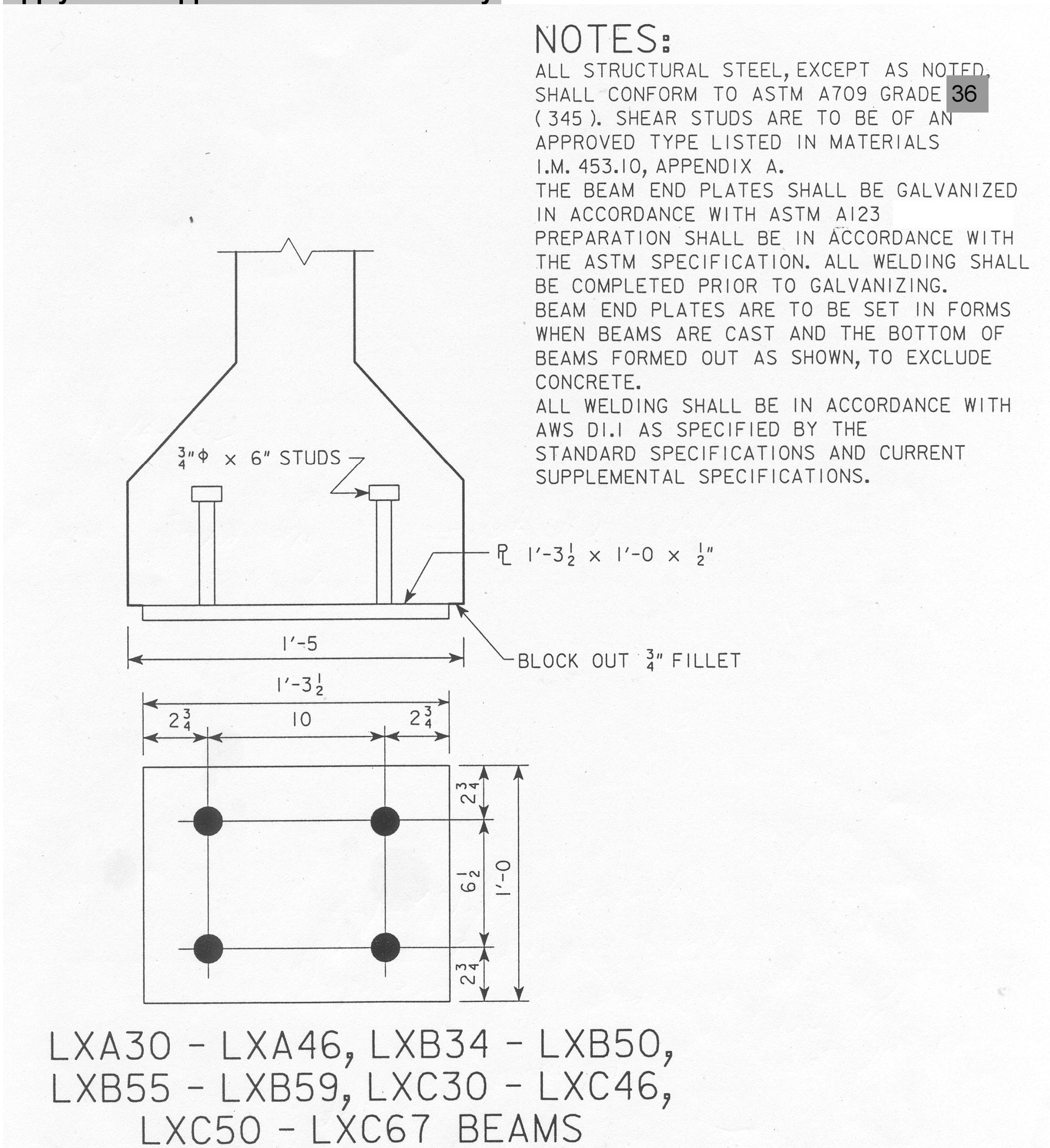


Figure 1. - Optional Beam Seat Protection Plate

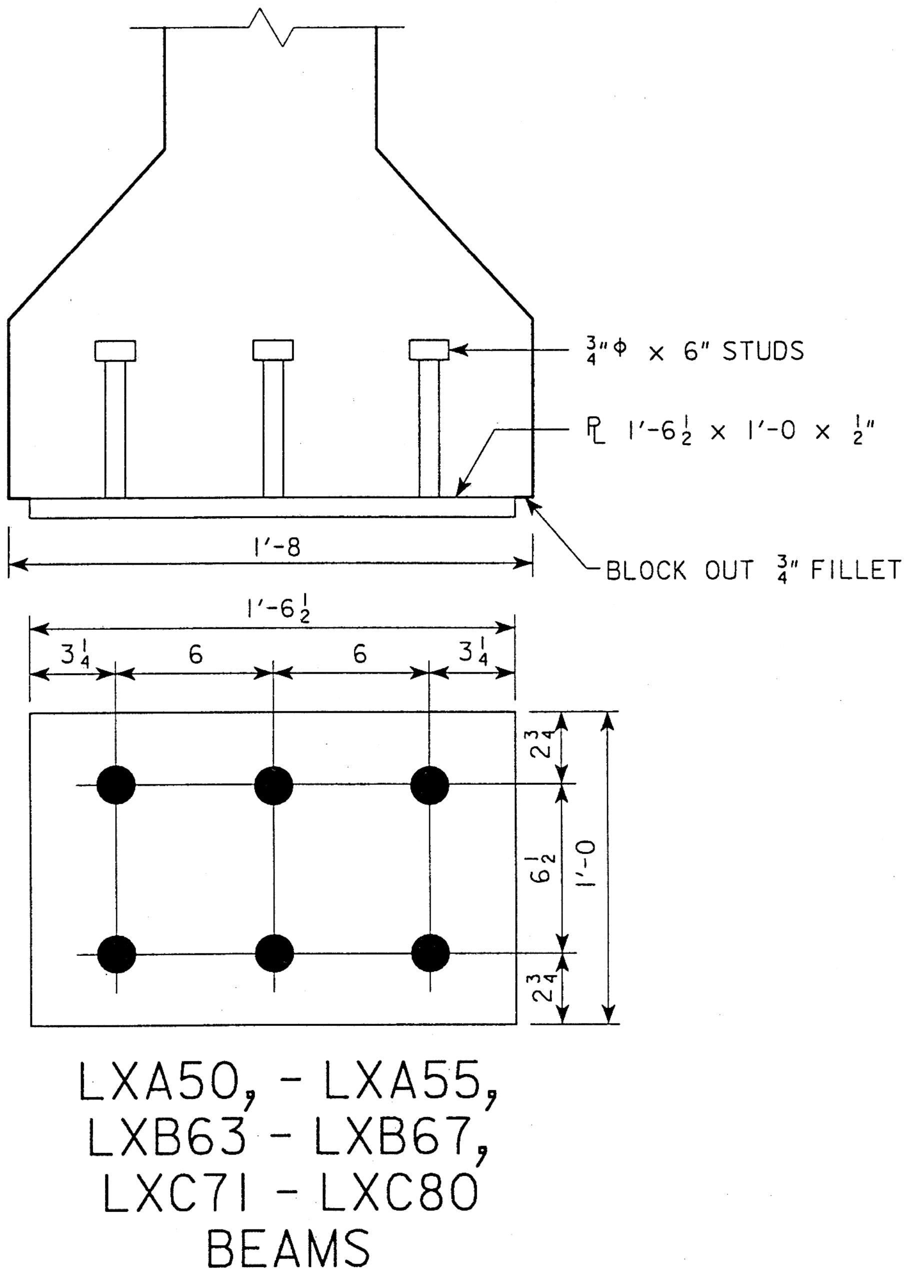


Figure 2. - Optional Beam Seat Protection Plate

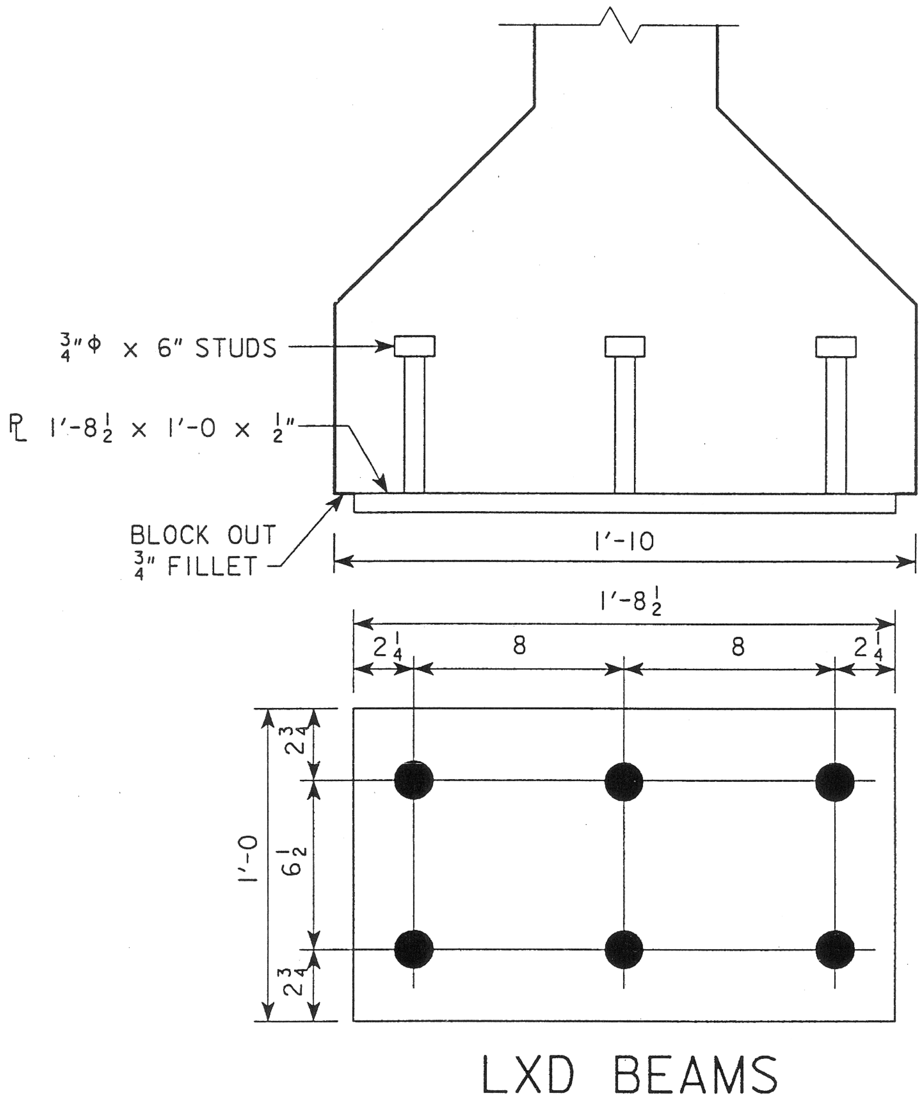
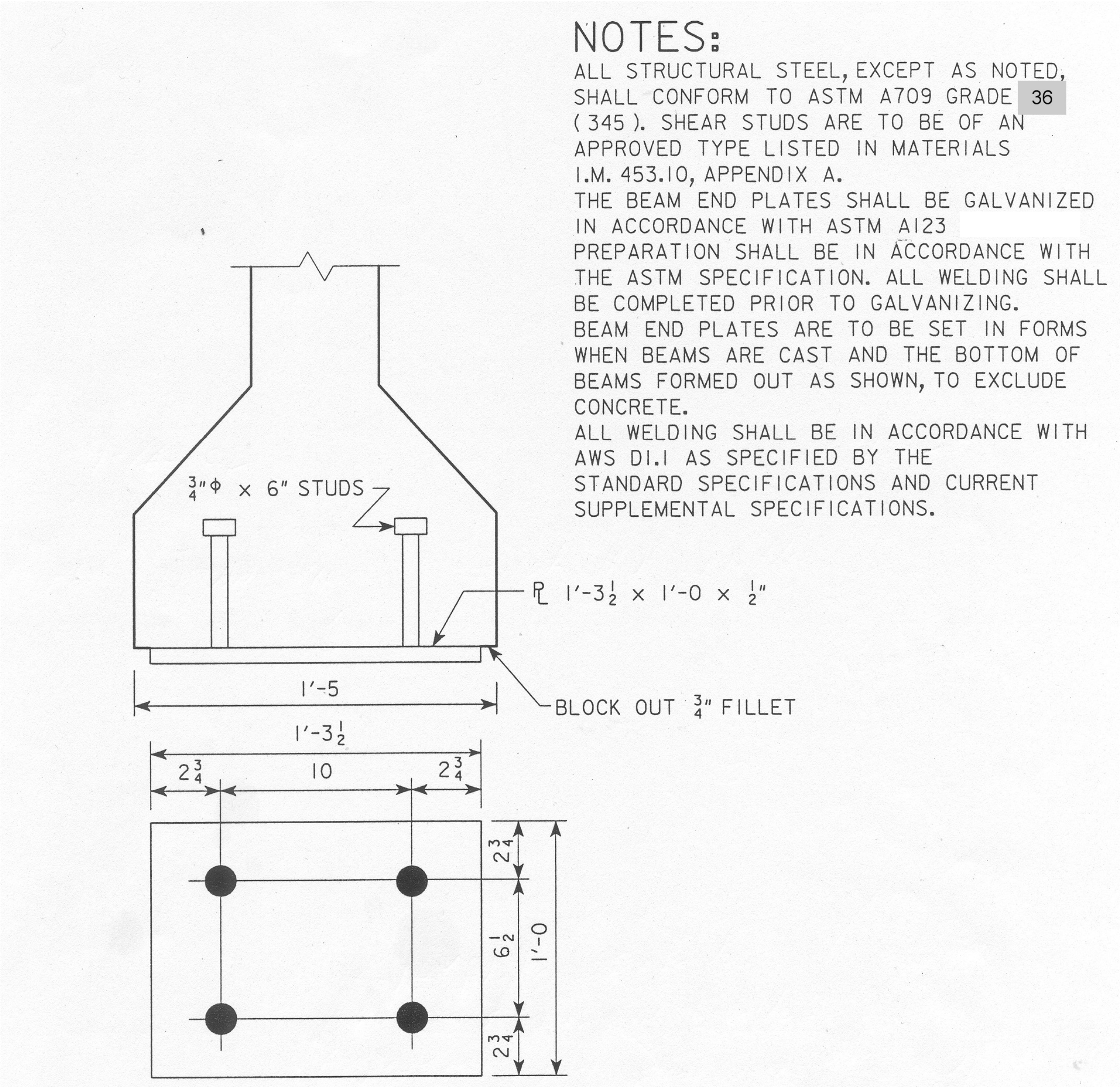


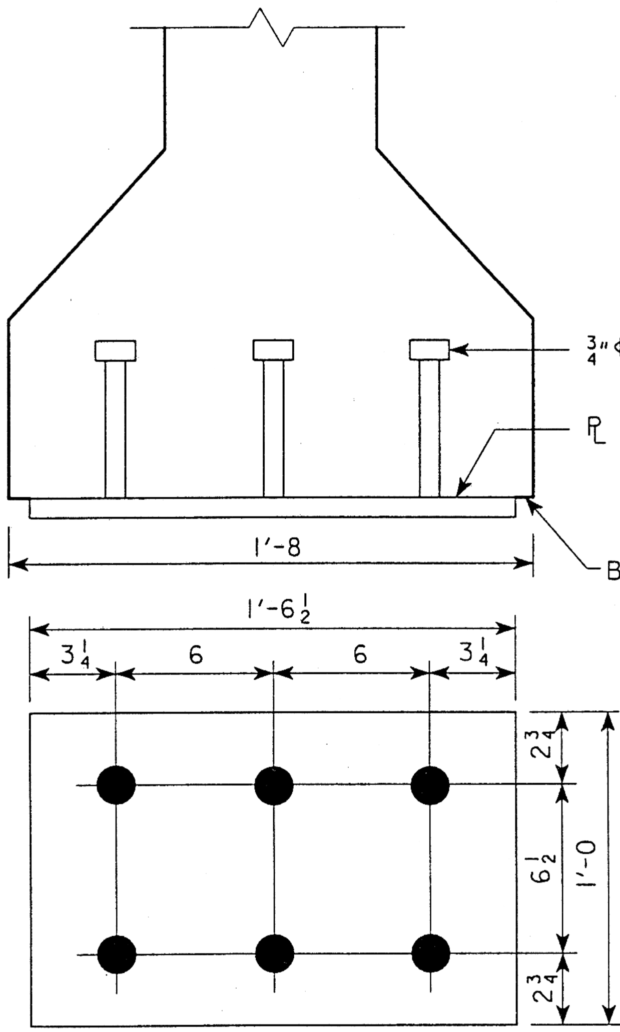
Figure 3. - Optional Beam Seat Protection Plate

Apply this IM appendix to LRFD beam only.



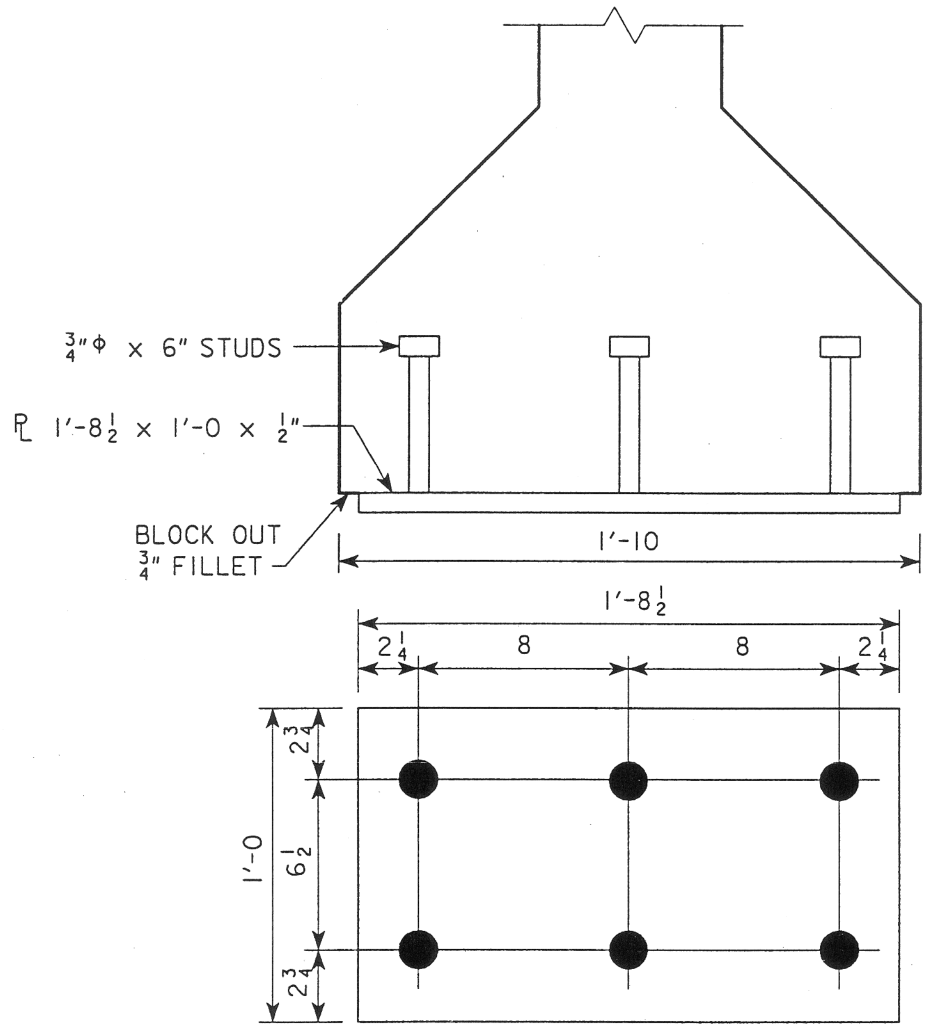
A and B BEAMS

Figure 1. - Optional Beam Seat Protection Plate



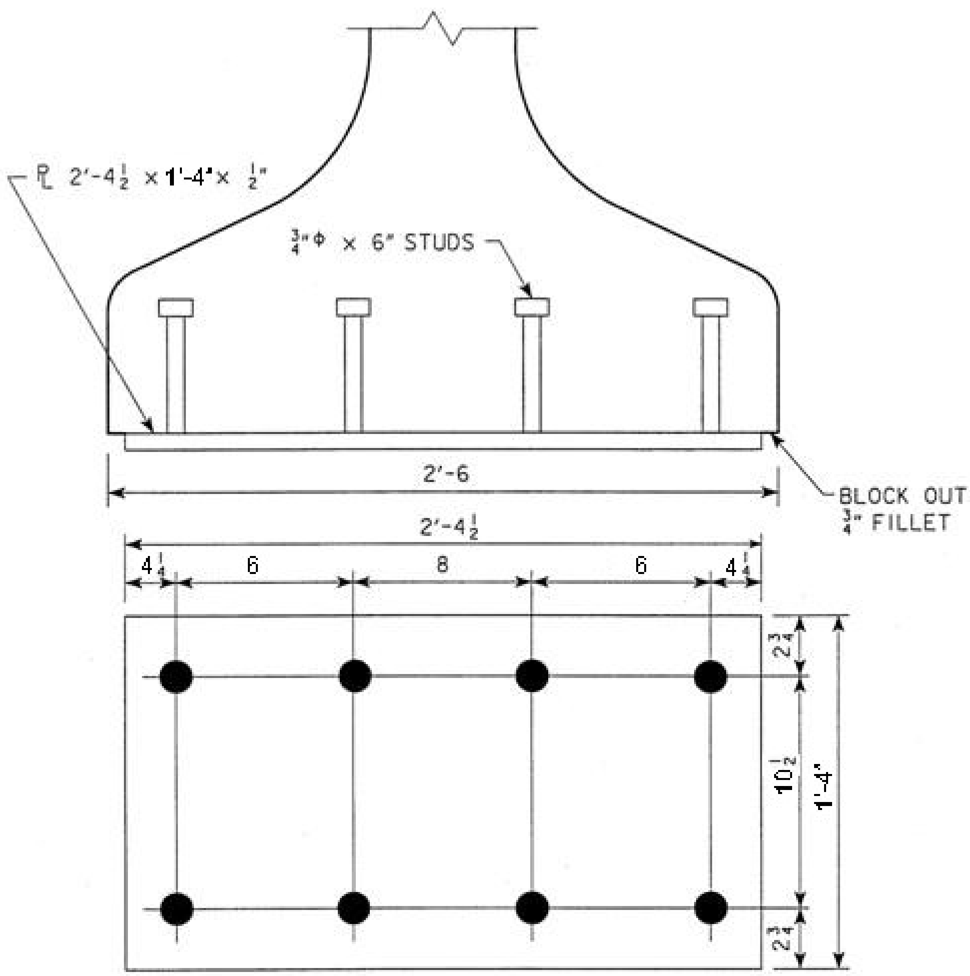
C BEAMS

Figure 2. - Optional Beam Seat Protection Plate



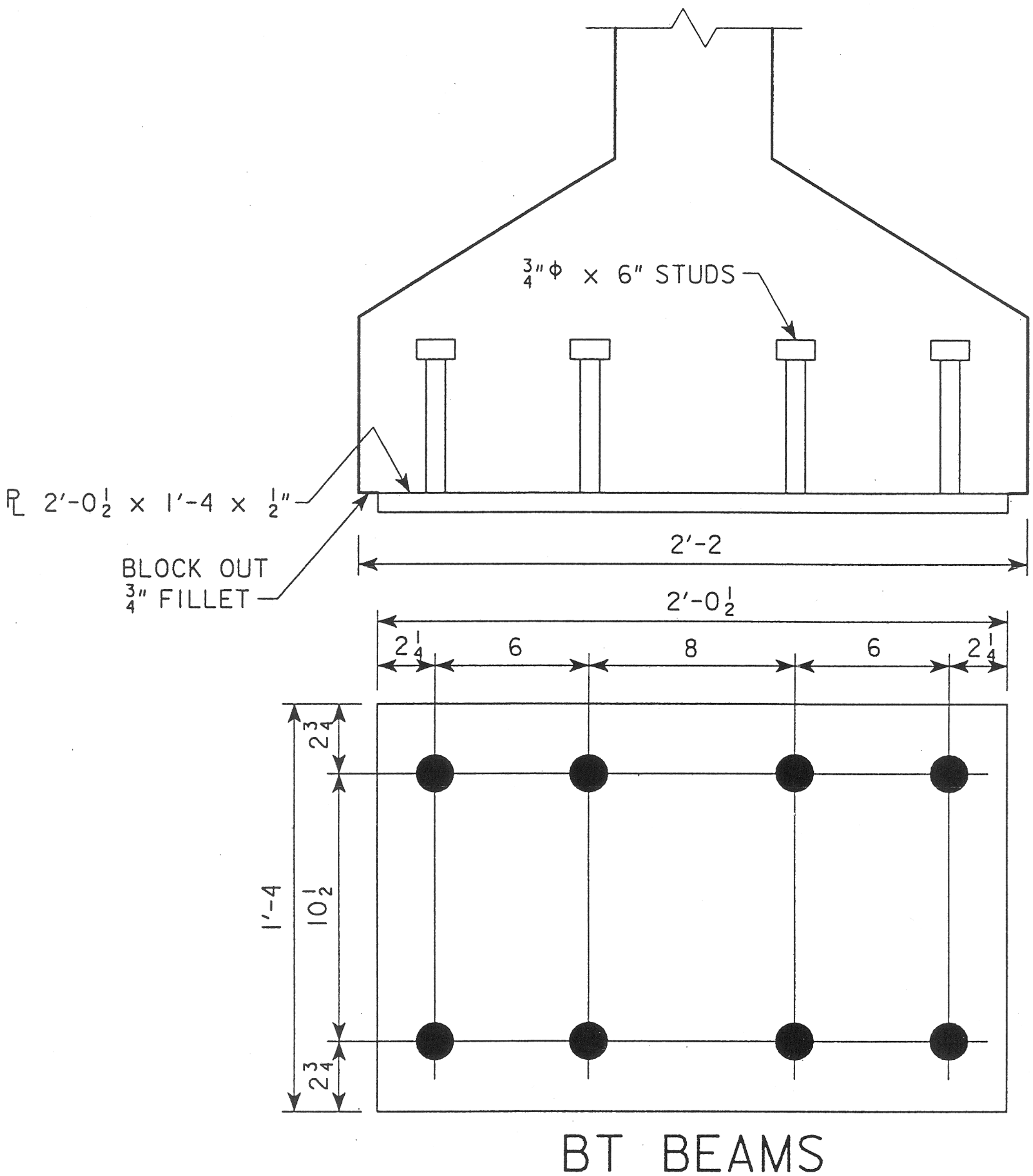
D BEAMS

Figure 3. - Optional Beam Seat Protection Plate



BTB, BTC, BTD, and BTE BEAMS

Figure 4. - Optional Beam Seat Protection Plate



BT BEAMS

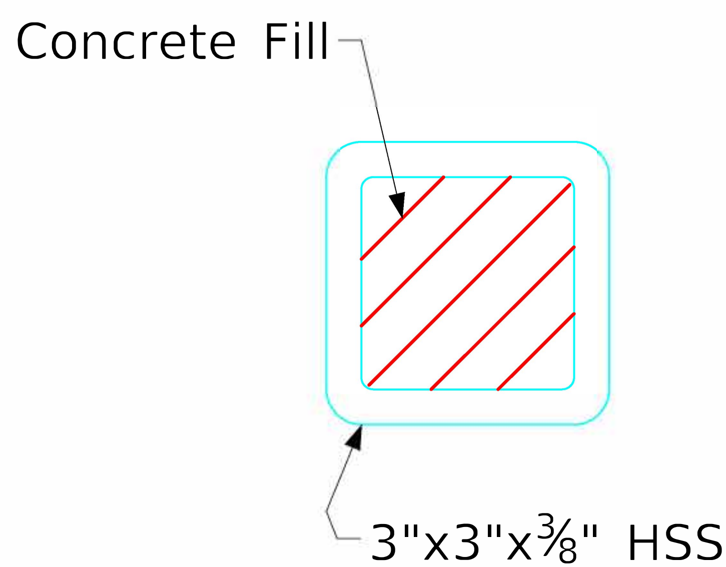
Figure 5. - Optional Beam Seat Protection Plate

Notes:

The material notes and details for integral abutment bearing bars as shown in this Appendix may be used as an alternate for the 3"x3" solid steel bar shown in the plans.

The alternate shall be 2'-4½" long.
In addition, SAE/AISI 1018 steel will be allowed as a substitute for A36 steel for the 3"x3" bar.

The alternate shown may also be used for the S3x7.5 section matching the lengths shown in the plans.



Material requirements:
HSS ASTM A501 Gr. 35 or ASTM A500 Gr. B
HSS Concrete Fill f'c = 5.0 ksi

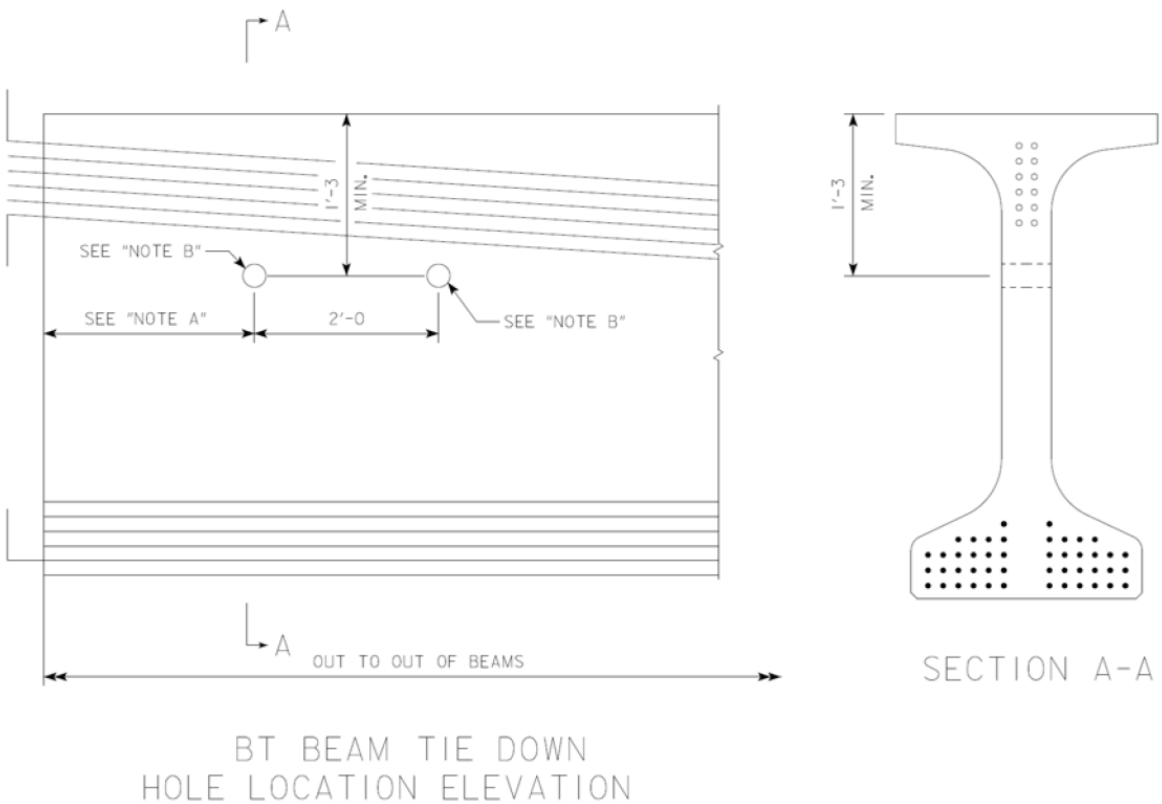
INTEGRAL ABUTMENT PPCB BEARING OPTION

For **BTD** and **BTE** beams only.

Optional Shipping Tie Down Holes for BTD and BTE Beams

Fabricators have the option of providing tie down details for BTD and BTE beams as shown in the figure and according to the following notes:

A. The tie down sleeve hole locations shall follow the beam overhang limits in the beam sheets in the bridge plans. Any changes to the sleeve hole locations shall be approved by the Engineer before casting.
B. The maximum diameter of the sleeve hole shall be 3 inches.
C. Sleeve holes shall be cast a minimum of 2 inches clear from any strands.
D. Centerline of the sleeve holes shall be a minimum of 1’-3” below the top of the top flange.



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Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns

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Vol. 30, No. 3, May-June 1985.

CHAPTER 3-CRACKS IN BEAMS

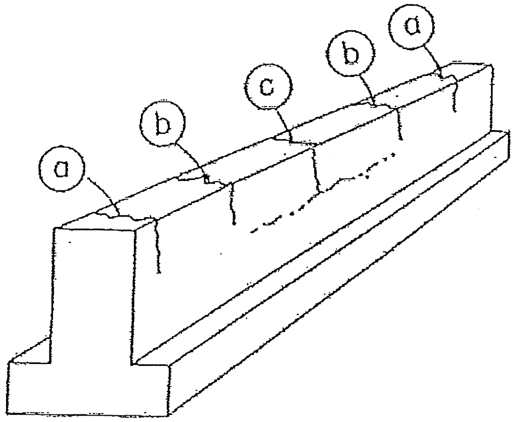
1. Transverse Crack at Top of Beam

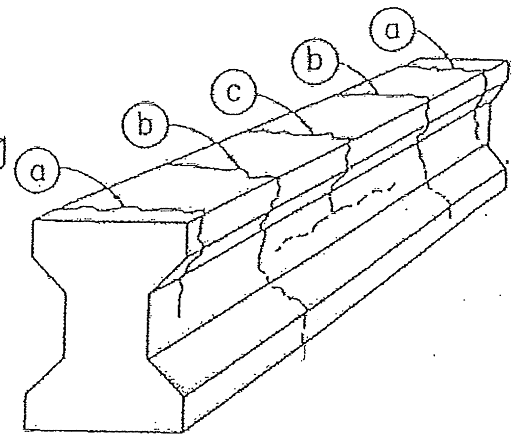
Description-These cracks are typically perpendicular to the longitudinal axis of the beam and they may extend across the top of the beam and be visible on both sides. In severe cases, they may extend to the full depth of the beam as shown in the figure for Crack 1b, so they may propagate parallel to the longitudinal axis near the centroid of the beam as shown in the figure for crack 1c.

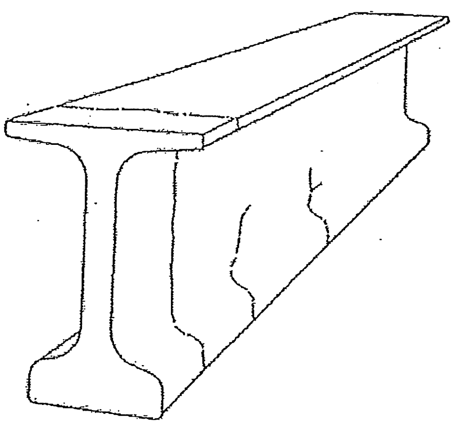
CAUSE	PREVENTION	EFFECT	REPAIR
A.Excessive top fiber tension	A. Reduce fiber tension.	Minimal for simple span beams unless subjected to a corrosive environment. Cracks 1b and 1c will tend to close as the beam is loaded in service position. Beams with topping will benefit from improved section properties which reduces the effect of cracking. Evaluate negative moment regions of continuous beams based on design assumptions, loca-tion, and size of cracks. If the crack extends horizontally (as shown by the dashed line in the fig-ure for Crack 1c) the condition may be less severe, and evaluation by an engineer is mandatory.	If crack causes a structural deficiency, then epoxy injection should be used. If crack has no structural implication, but will be exposed to a corrosive environment, then epoxy injection or coating should be considered.
1.Inadequate top reinforcement.	1.Proper design of top steel for stresses (See AASHTO Standard or LRFD Specifications)		
2.Incorrect top reinforcement or incorrect placement of top reinforcement.	2.Improve inspection prior to concrete placement and correct for subsequent easts.		
3.Low release strength.	3.Increase release strength		
4.Lack of strand debonding at end of beam (Crack 1a).	4.Base debonding on stress limitations of section and use inspection prior to concrete placement to confirm specified debonding.		
5.Improper location of lifting or dunnage points (Cracks 1b and 1c).	5.Maintain proper lifting and dunnage locations. Avoid use of more than two dunnage points. If more than two dunnage points must be used, assure that full bearing is achieved at all points.		
6.Prestress uplift at midspan exceeds weight of member or exceeds beam's top fiber tensile capacity (Crack 1c).	6.Add weight to midspan before release to offset uplift, or add reinforcement to minimize cracks (even when reinforcement is provided, section may crack as reinforcement takes on tensile load.		
B. Shrinkage.	B. Apply covers rapidly and/or mist spray with water.		
C. Delayed detensioning of heat cured products.	C. Detension as covers are removed and do not allow section to cool rapidly.		
D. Form expansion with curing temperature rise if preset time is inadequate (Crack 1a).	D. Lengthen preset time-Determine in accordance with ASTM C403.		
E. Excessive side fiber tension (Crack 1a).	E. Reduce side fiber tension.		
1.Excessive lateral displacement during transportation. This crack usually extends the full height of the section in I girders, as shown by the dashed line in the figure.	1.Provide lateral strongbacks or transport two members strapped together.		

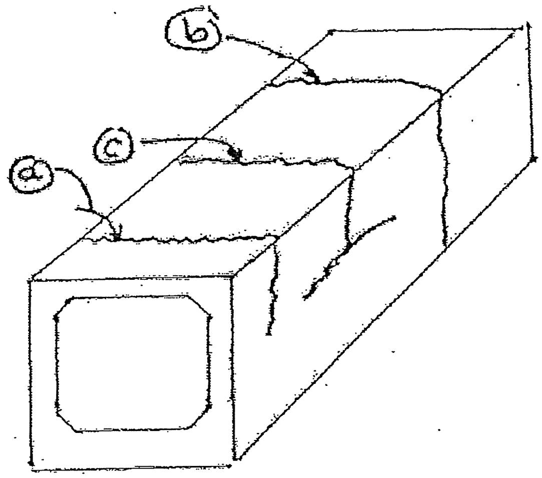
1. **Transverse Crack at Top of Beam (cont.)**

NOTES: 1a Located near end of beam
1b Located between end and center of beam
1c Located near center of beam









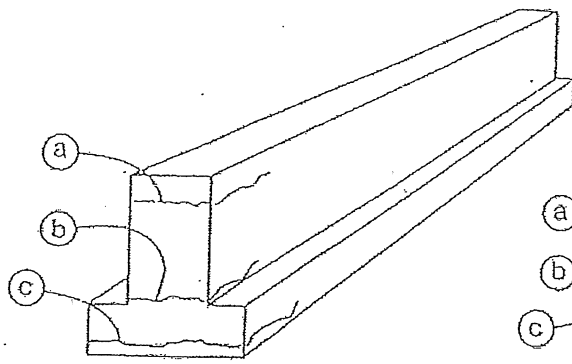
2. Horizontal End Crack in Web or Flange

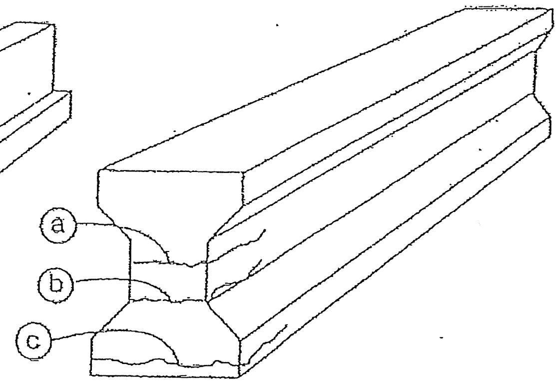
Description-This crack usually begins at the end of the beam and extends horizontally for a distance from several inches to a few feet. It is often located in the horizontal plane of the strand. The crack will sometimes extend across the end of the beam and be visible on both sides.

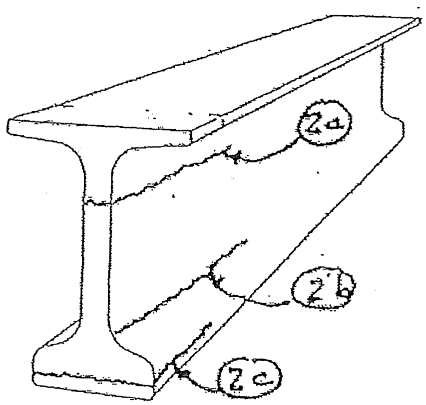
CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper handling and stripping. 1.Improper header removal. 2.Strand caught in header. B. Improper production. 1.Indentations or joint offsets in forms. 2.Binding in forms. C. Improper release. 1.Improper procedure for detensioning. 2.Improper detensioning sequence. 3.Low release strength. 4.Slippage and impact from dirty strand. D. Improper design. 1.Inadequate confining reinforcement. 2.Excessive prestress force or concentration of prestress force. 3.Improper choice of masked strand, or lack of confining reinforcement. E. Settlement of concrete under a concentration of reinforcement near the top of the beam (Crack 2a). F. Differential stresses between web and flange during detensioning or inherent in the design (Crack 2b). G. Insufficient cover over the bottom row of strands (Crack 2c).	A. Better stripping and handling techniques. 1.Separate header from beam before lifting. 2.Allow member to drift away from headers when lifting. B. Improve production methods. 1.Keep forms in good repair. 2.Keep forms clean and properly oiled. C. Proper release. 1.Anneal strand prior to cutting. 2.Keep prestress force balanced while detensioning. 3.Achieve proper strength prior to releasing strand. 4.Keep strands clean. D. Improve design. 1.Use adequate end reinforcement. 2.Properly space and distribute strand at the ends of members. 3.Masking must allow for expansion and twisting of masked strands. Do not debond entire plane of strand or the outermost strand in a layer and provide confining reinforcement. E. 1.Use sufficient vibration. 2.Allow time for initial settlement and revibrate the concrete. 3.Reduce maximum aggregate size in the concrete mix. F. 1.Provide additional end confining reinforcement. (This will not necessarily eliminate the crack, but should control it.) 2.Revise detensioning sequence to limit differential stresses. G. Provide sufficient cover. (This may require moving the strand to a different position.) H. Add protection plates at beam-ends.	If the plane of the crack does not coincide with the prestressing reinforcement, the effect is minimal. The end reaction provides a clamping force for this type of crack. If the plane of the crack coincides with prestressing reinforcement, there is a possibility of loss of bond. This could reduce the shear and moment capacities near the end of the member due to reduced prestress force.	If crack causes a structural deficiency, then epoxy injection should be used. If crack has no structural implication, but will be exposed to a corrosive environment, then epoxy injection should be considered.

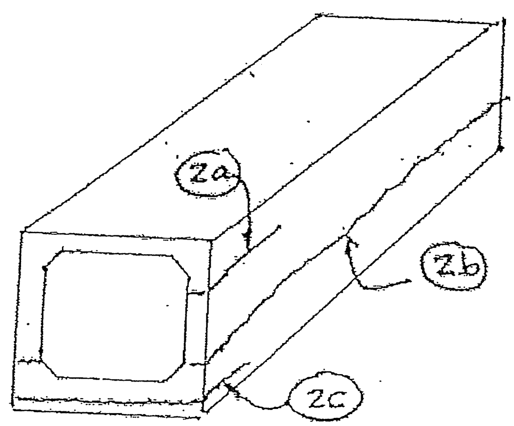
2. <u>Horizontal End Crack in Web or Flange (cont.)</u>

NOTES: 2a Located in the web.
2b Located at the junction of the web and flange.
2c Located in the bottom flange.









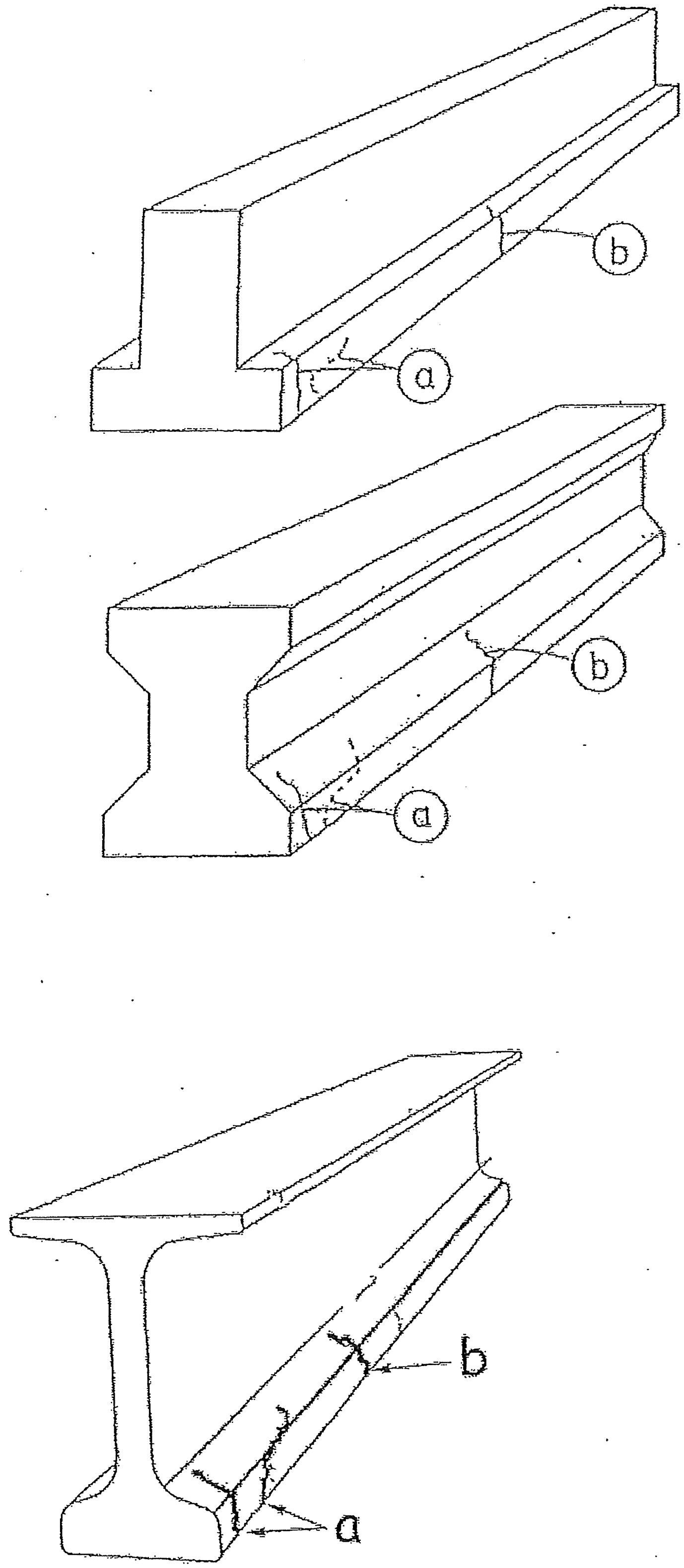
3. Vertical and Diagonal Cracks at Bottom of Member

Description-Thick crack starts at the bottom of the member and extends upward. In severe cases, the cracks will extend diagonally toward the center of the member, as shown by the dashed line the figure.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper production. 1.Indentions or joint offsets informs. 2.Binding in forms. 3.Bottom plate at end of member anchored or restrained in form (Crack 3a). 4.Improper end curing(Crack 3a).	A. Improve production methods. 1.Keep forms in good repair. Fabricate forms with even, smooth joints. 2.Keep forms clean and properly oiled. 3.Avoid restraint of plates. 4.Prevent heat loss at headers.	Cracks crossing strands near the end of a member can be very serious because of the possibility of loss of bond between the end of the member and the crack as well as the increased transfer length beyond the rack. Shear is very much a problem unless the member has stirrups or confining reinforcement. If no bond failure of strands has occurred at the ends, the flexural strength is not affected. if strnd slippage has occurred, check member capacity based on reduced prestress. Member is not serviceable unless its capacity is verified by test or calculations. A reduced service load may be considered in some cases.	Epoxy injection can restore the shear strength of the concrete if there is sufficient bonded reinforcement. Epoxy injection will not restore loss of bond or substitute for insufficient reinforcement.
B. Incorrect reinforcement. 1.Inadequate reinforcement. 2.Incorrect placement of reinforcement. 3.Improper strand tensioning. 4.Prestress losses underestimated.	B. Verify that the correct reinforcement is being used. 1.Check design calculations for possible error. Use inspection prior to concrete placement to confirm proper type and quantity of reinforcement. 2.Place reinforcement in its specified location and use inspection prior to concrete placement to confirm reinforcement details. 3.Compare measured strand elongation versus computer elongation. 4.Recompute losses.		
C. Bond Failure of strands at end of member. 1.Foreign matter on strands. 2.Insufficient vibration.	C. Prevent bond failures. 1.Keep strands clean. 2.Vibrate properly.		
D. Debonding of all bottom strand at the point of bearing (Crack 3a).	D. Some strands, particularly those closest to the sides of the member, must be bonded to reinforce this area.		
E. Improper release. 1.Low release strength. 2.Improper procedure for dentioning strands (Crack 3a). 3.Improper dentensioning sequence(Crack 3a). 4.Improperly masked strand (Cracked 3a).	E. Proper release. 1.Achieve proper strength prior to releasing strand. 2.Anneal strand prior to cutting. 3.Keep prestress force balanced while cutting strands. 4.Base deboning on stress limitations of section and use inspection prior to concrete placement to confirm specified debonding. provide confining reiforcement around masked strands. Strands located near the side face should not be debonded unless absolutely necessary.		
F. Improper storage or handling of members designed to be cantilevered (Crack 3b).	F. Lift and support cantilever members as close to bearing points as possible.		

3. <u>Vertical and Diagonal Cracks at Bottom of Member (cont.)</u>

NOTES: 3a Located near the end of the member
3b Loacted near the center of the member



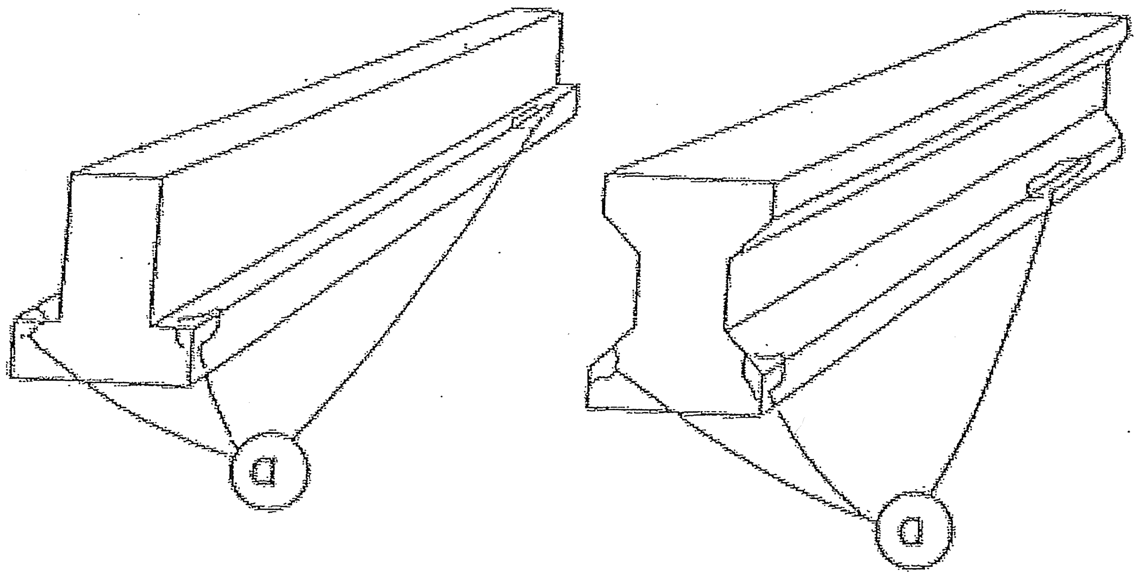
4. Ledge Corner Crack

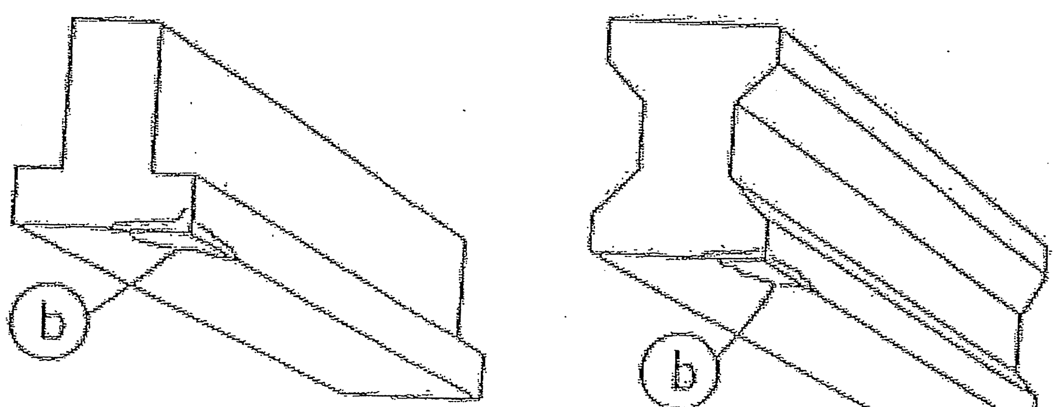
Description-Diagonal crack at the edge of the flange. Crack 4a, located in the top of the flange can occur anywhere along the length of the member. Crack 4b, located in the bottom of the ledge, is usually located at the end of the member.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper handling 1.Bumping edges when handling. 2.Uneven dunnage (Crack 4b) B. Improper production. 1.Binding in form during stripping 2.Indentations in form. 3.Inserts hanging up in forms. 4.Bottom plate at end of member not flush with header (Crack 4b). 5.Improperly masked strands. C. Improper release. 1.Improper detensioning sequence. 2.Binding in form during detensioning.	A. Proper handling. 1.Allow adequate clearance while handling. 2.Use dunnage which provides uniform bearing. B. Improve production methods. 1.Keep forms clean and properly oiled. 2.Keep forms in good repair. 3.Ensure that inserts are free during stripping. 4.Place bottom plate flush with header and secure. 5.Base debonding on stress limitations of section and use inspection prior to concrete placement to confirm rein-forcement around masked strands. Strands located near the side face should not be debonded unless absolutely necessary. C. Proper release. 1.Keep prestress force balanced while dentioning. 2.Keep forms properly oiled and in good repair.	For cracks in the top of the flange, if there is not a member bearing on the crack the only problem is cosmetic. Where members bear, there will be a reduction in the bearing capacity and if transverse reinforcement is missing or improperly placed, the load carrying capacity is greatly reduced. Cracks in the bottom of the flange can reduce the bearing area or expose reinforcement, but generally they have little effect.	Minor cracks in nonbearing areas require only cosmetic patching. In bearing conditions with adequate reinforcement the bearings area should be restored with epoxy injection or other suitable material or a steel section may be used to transfer load to an unaffected area. If transverse reinforcement is missing an auxiliary support, such as a steel bracket, may be required. Spalls should be patched to cover reinforcement.

4. <u>Ledge Corner Crack (cont.)</u>

NOTES: 4a Loacted at top of ledge
4b Loacted at bottom of ledge

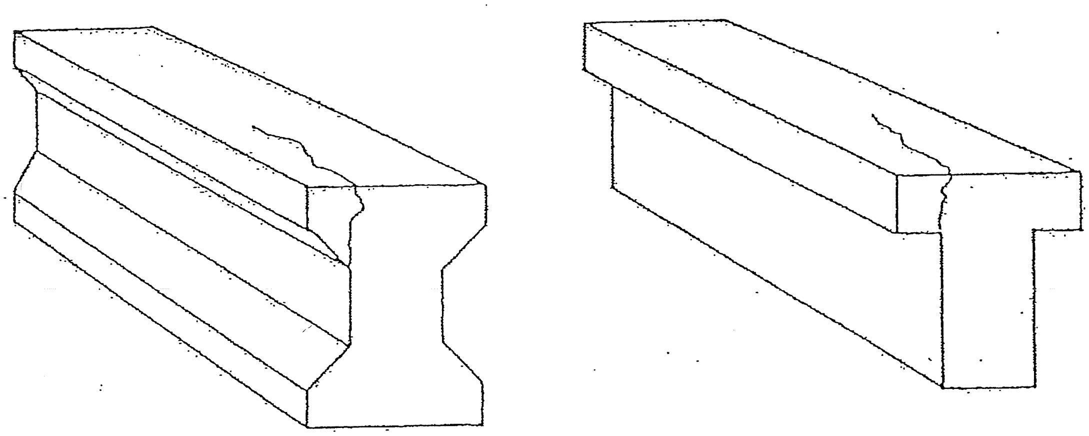




5. Ledge Crack

Description-Crack originates at the intersection of the web and flange and extends toward the bottom of the member. The crack is located at the end of the beam.

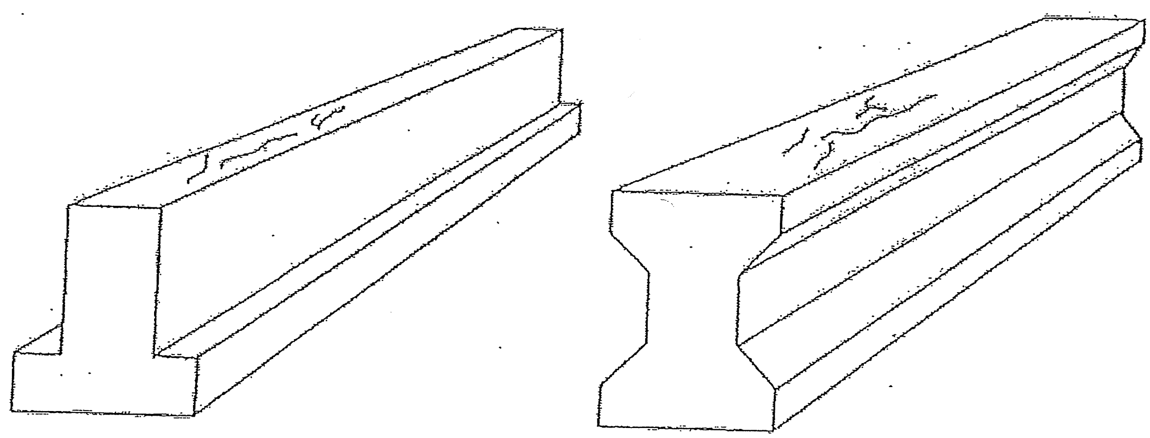
CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper production. 1.Binding in form during stripping. 2.Indentations in form. 3.Improper detensioning scequence. A. Incorrect reinforcement 1.Incorrect placement of reinforcement. 2.Reinforcement improperly fabricated.	A. Improve production methods. 1.Keep forms clean and properly oiled. 2.Keep forms in good repair. 3.Keep prestress force balanced while detensioning. B. Verify that the correct rein-forcement is being used and use inspection prior to concrete placement to confirm rein-forcement details. 1.Place reinforcement in its proper location. 2.Check for proper detailing and fabrication of reinforcement.	The load carrying capacity of the ledge is impaired and the bearing area of the beam itself is reduced. If reinforcement is missing the capacity must be investigated.	In cases where there is no load on the ledge, or where there is suffient reinforcement perpendicular to the crack, epoxy injection may be used. Where the ledge is required to support load and there is insufficient reinforcement, an auxiliary support such as a steel bracket secured to the web of the beam may be used.



6. Miscellaneous Cracks

Description- Fine, shallow cracks in the top surface of the beam, occurring in a random pattern or parallel with reinforcement.

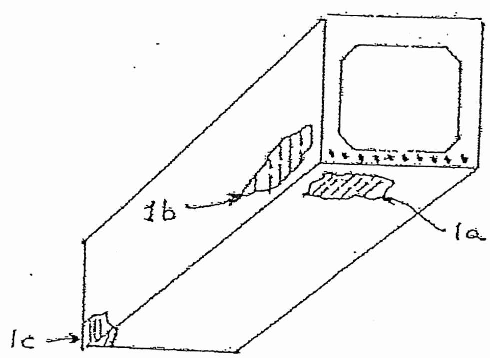
CAUSE	PREVENTION	EFFECT	REPAIR
A. Surface shrinkage. 1.Excess water in concrete. 2.Rapid moisture loss.	A. Proper mix and curing. 1.Reduce water in concrete. 2.Use retarding admixtures. Cover product completely and as soon as possible (especially in windy, hot, or dry exposures). If necessary, spray mist product with water or curing compound before covering.	Minor, but can be serious in a corrosive environment. If the reinforcement in the top of the beam is prestressed, the potential loss of bond should be investigated.	If required, inject with epoxy or patch with grout.
3.Heat applied too early in the curing cycle.	3.Lengthen preset time. Determine in accordance with ASTM C403.		
4.Excessive curing temperatures.	4.Reduce curing temperatures.		
B. Settlement of concrete around top reinforcement (subsidence).	B. Allow time for initial settlement and revibrate the concrete.		
C. Insufficient vibration.	C. Use sufficient vibration to eliminate voids under top reinforcement.		

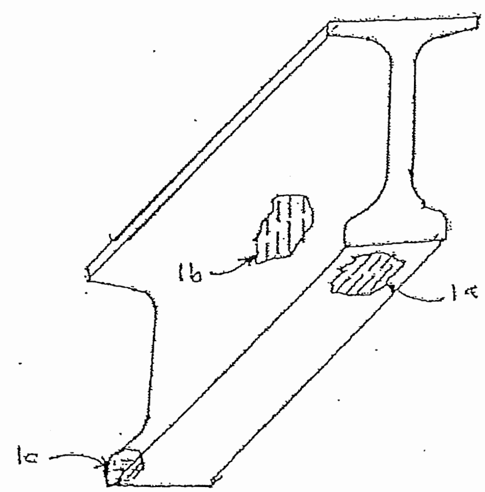


7. Random Voids

CAUSE	PREVENTION	EFFECT	REPAIR
A. Inadequate vibration	A. Use both internal and external vibration.	Non, provided suitable patching materials are used, and surfaces adequately prepared	Prepare the area to be patched by removing all unsound concrete, dust, oil, grease and other contaminates. Square all edges. The minimum depth of patches should be ½". Clean all steel by wire brushing or sandblasting. Flush area to be patched and keep substrate damp until patching material is applied.

NOTE: 1a,b,c Inadequate vibration





pci JOURNAL
PRECAST/PRESTRESSED CONCRETE INSTITUTE

Evaluation of Degree of Rusting on Prestressed Concrete Strand

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Evaluation of Degree of Rusting on Prestressed Concrete Strand

Presents a procedure for classifying the degree of rust on a piece of prestressing strand and discusses the reasons for acceptance or rejection of each classification. Visual standards are developed by which inspectors can identify the degree of corrosion at which pitting occurs.

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Jacksonville, Florida
Current Chairman
PCI Committee on Prestressing Steel

The presence of rust on prestressing steel strand has been a source of controversy between the user and supplier of strands. This is due, at least in part, to a lack of a clear understanding of how much rust can exist on the strand surface without any detriment to the performance of the strand. This paper is an attempt to clarify this problem and to provide reliable guidance to inspectors in deciding when to accept or reject a particular strand.

Bright strand refers to the surface quality of uncoated strand with no signs of rusting. This type of surface finish is obtained by the conventional dry drawing process, followed by stranding and the stress relieving operation.[1] Photo 1 shows a typical strand surface before cleaning.

Rust is a brownish-red substance which forms on the surface of iron or steel when it is exposed to damp air. The term rust, when used alone, means iron rust. Note that iron rust consists mainly of hydrated iron oxide. Rust is formed by the reaction of oxygen with iron by the chemical process known as oxidation. Moisture is an essential agent in producing rust.

When prestressing strand is exposed to a humid atmosphere, the original bright surface condition of the strand will not last very long. Weathering, which is the initial stage of oxidation, starts to take place. It is difficult to determine the degree of weathering until visible rust begins to appear on the strand surface. Rusting will inevitably take place when the weathered surface is continuously exposed to dampness or a humid atmosphere.

The material standard specification for seven-wire prestressed concrete strand, ASTM A 416, states in Section 8.4 that "Slight rusting, provided it is not sufficient to cause pits visible to the unaided eye, shall not be cause for rejection."[2] The *Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products* published by PCI,[3] under Section 2.2.2, does not necessarily consider the presence of light rust on strand a problem because it has proven not to be detrimental to the bond. In the last paragraph of that section, it says that "If no pitting has developed on the strand surface, then no effective loss of strand area has occurred."[3] This document will be referred to as the PCI Manual in the succeeding text.

Another industry reference which allows slight rusting in prestressing steel is the FIP document[4] entitled, *Recommendations for Acceptance of Post Tensioning Systems.* Section 4.1 of the May 17, 1991, version of this document states that "Slight and uniformly distributed corrosion (with no pitting) is not always entirely avoidable and has no detrimental effects on the mechanical properties and durability of prestressing steel."[4]

All the preceding documents dislike the presence of pits on prestressing strand and recommend that pitted strand be cause for rejection. However, only the PCI Manual has a recommended procedure which can assist field inspectors to accept or reject strands with rust. The PCI Manual recommends the use of a pencil eraser to expose the pits.[3] Nevertheless, this method is not practical because the pencil eraser

1

Photo 1. Strand surface before cleaning.

1A

Photo 1A. Strand surface after cleaning.

2

Photo 2. Strand surface before cleaning.

2A

Photo 2A. Strand surface after cleaning.

3

Photo 3. Strand surface before cleaning.

3A

Photo 3A. Strand surface after cleaning.

4

Photo 4. Strand surface before cleaning.

4A

Photo 4A. Strand surface after cleaning.

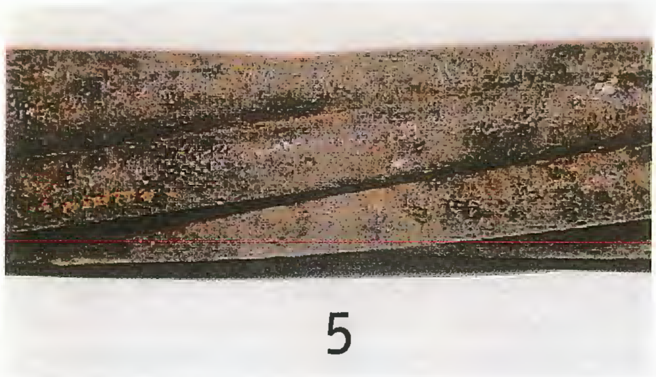


Photo 5. Strand surface before cleaning.

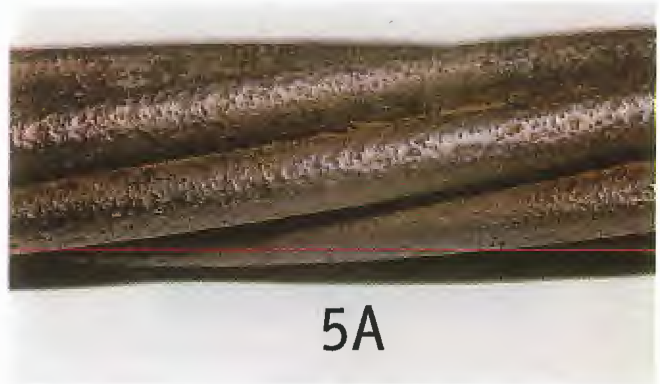


Photo 5A. Strand surface after cleaning.

Photo 6. Strand surface before cleaning.

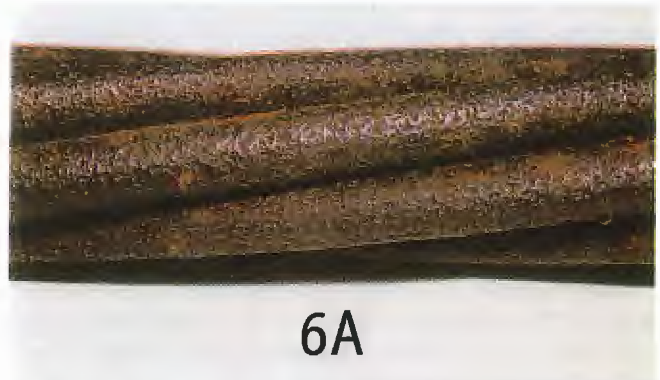


Photo 6A. Strand surface after cleaning.

Photo 7. Strand surface before cleaning.

Photo 7A. Strand surface after cleaning.

Photo 8. Strand surface before cleaning.

Photo 8A. Strand surface after cleaning.

Photo 9. Scotch Brite Cleaning Pad.

can expose only a very small area of the strand, and it will take a long time to clean a wider area for better observation. Thus, in this paper, the use of a Scotch™ pad for cleaning the strand is recommended to remove the corrosion products and expose the pits.

This paper describes a method to establish visual standards which identify the degree of corrosion in a strand at which pitting occurs. This guide will help field inspectors make proper judgments on the suitability of strand.

Visual standards are established by photographing samples of strand with varying degrees of rust as illustrated in Photos 1 through 6. For publication purposes, the pictures are scaled down. However, the actual examination will be done by inspectors using the unaided eye.

Photo 1 represents a new strand with no rust and has a bright surface. Photos 2 through 6 illustrate various amounts of corrosion on strand samples that were exposed to a corrosive environment for different lengths of time and include some pits that are to be considered cause for rejection.

What is cause for rejection and why?

Light rust does not harm any of the properties of the strand and it actually enhances bond. Rust alone is not a cause for rejection.

A pit visible to the unaided eye, when examined as described herein, is cause for rejection. A pit of this magnitude is a stress raiser and greatly reduces the capacity of the strand to withstand repeated or fatigue loading. In many cases, a heavily rusted strand with relatively large pits will still test to an ultimate strength greater than specification requirements. However, it will not meet the fatigue test requirements.

In order to evaluate the extent of pitting, the superficial rust has to be removed. In the samples described herein, care was taken to not abrade the strand surface below the iron oxide or rust layer. This was accomplished by cleaning the surface with Scotch Brite™ cleaning pads in order to expose the pits. Scotch Brite Cleaning Pad No. 96, made by 3M, or its equivalent, is a synthetic material which is nonmetallic. This material is available from cleaning supply retailers or supermarkets for general purpose cleaning. A sample of this material is shown in Photo 9.

Cleaning is accomplished by holding a new pad by hand and rubbing it against the strand surface longitudinally along the strand axis. The amount of pressure exerted on the pad against the strand is equivalent to that when cleaning pots and pans.

After the samples were cleaned, additional photographs were taken and these are marked as Photos 1A through 6A. All pictures with the suffix "A" were taken after cleaning and are placed next to those taken prior to cleaning for ease in making the comparison.

These pictures can be used as visual standards from which the user and supplier may agree on the surface quality that is acceptable. Following the above-mentioned procedure, the strand in question may be accepted or rejected by comparing the cleaned surface with the picture that was previously agreed upon as the standard.

It is the opinion of the writer that Picture Sets 1 through 3 are acceptable. Picture Set 4 is borderline and is subject to discussion, agreement or compromise. Some engineers may find this level of rusting objectionable for critical applications. Picture Sets 5 and 6 are pitted and unacceptable.

The corrosion and pitting in the center wire were examined. A rusty strand sample shown in Photo 7 has corroded the outer wires with the same degree of pitting as in Picture Set 5. After cleaning with a Scotch Brite pad, the pitted surface is revealed as shown in Photo 7A.

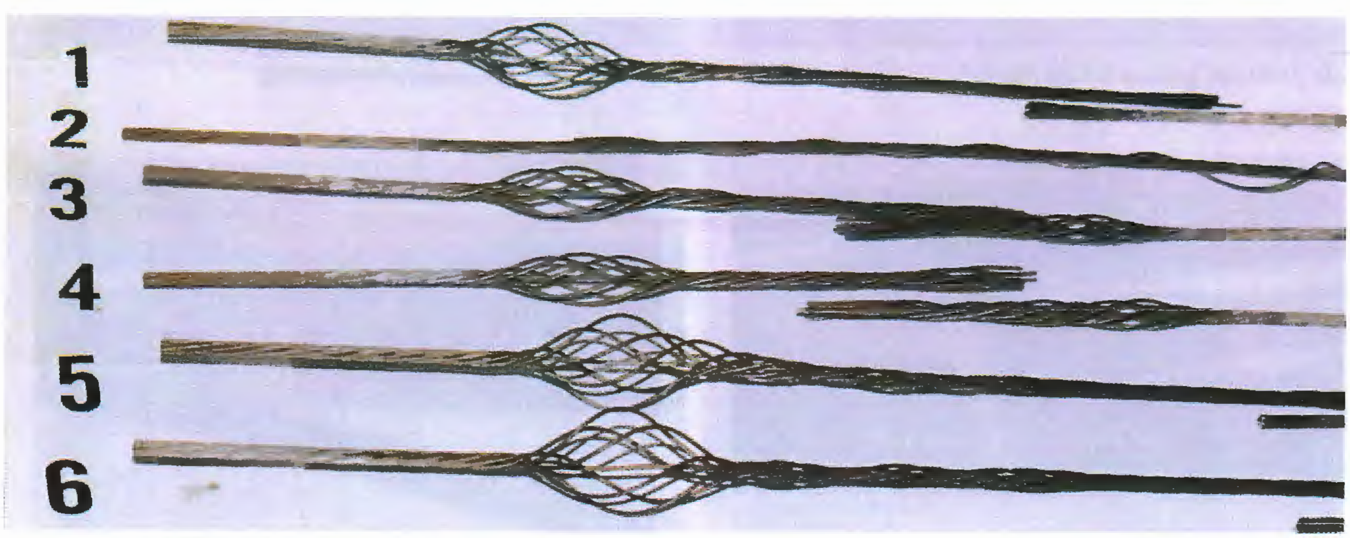


Photo 10. Samples after testing for mechanical properties.

Table 1. Mechanical properties of strand.

Sample No.*	Breaking strength, lb	Load at 1 percent extension, lb	Ultimate elongation, percent
1	43,800	40,000	5.00
2	43,700	39,800	4.95
3	43,500	39,700	5.73
4	43,300	39,600	5.21
5	42,800	38,900	5.73
6	42,400	38,800	5.21

* Designation corresponds to the surface conditions shown in Photos 1 through 6.
Note: 1 lb = 4.448 N.

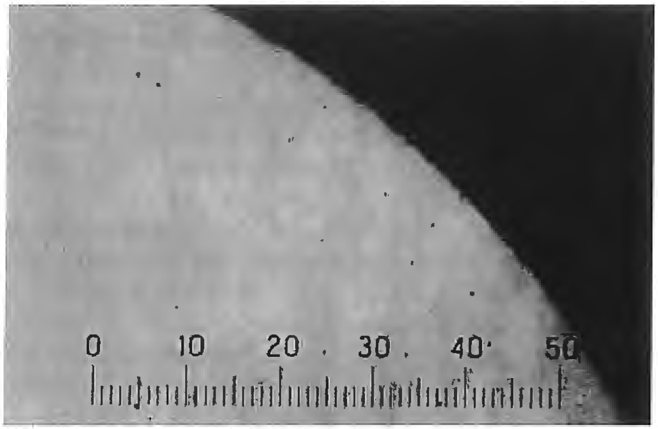
Table 2. Results of bend test on strand.

Sample No.	Number of 90-deg. bends
1	15
2	15
3	14
4	9
5	7
6	5

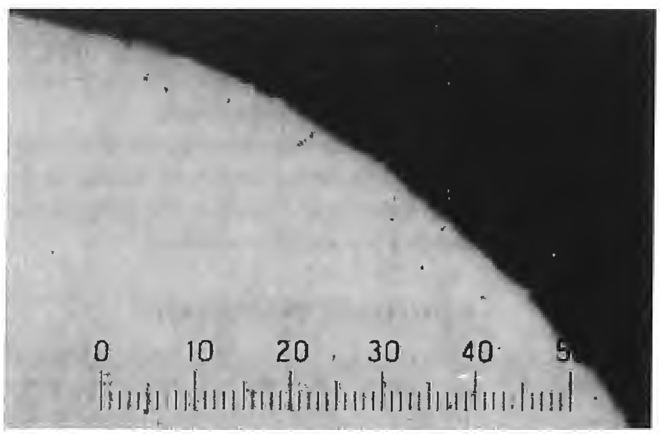
Table 3. Depth of pits on strand. [Note: 1 in. = 25.4 mm.]

Photomicrograph No.	Depth, in.
1	*
2	*
3	*
4	0.0008
5	0.0031
6	0.0077

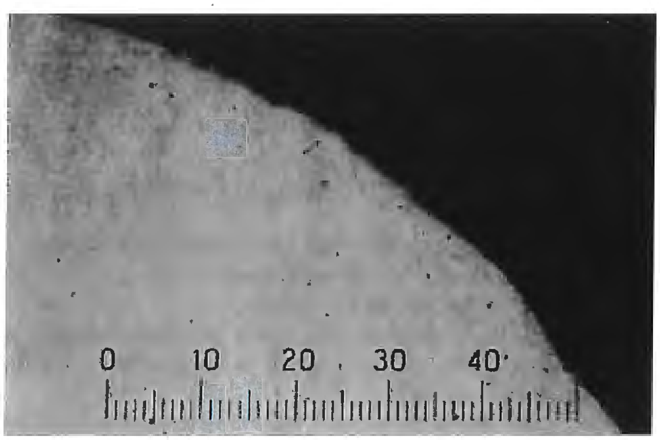
* Not measurable.



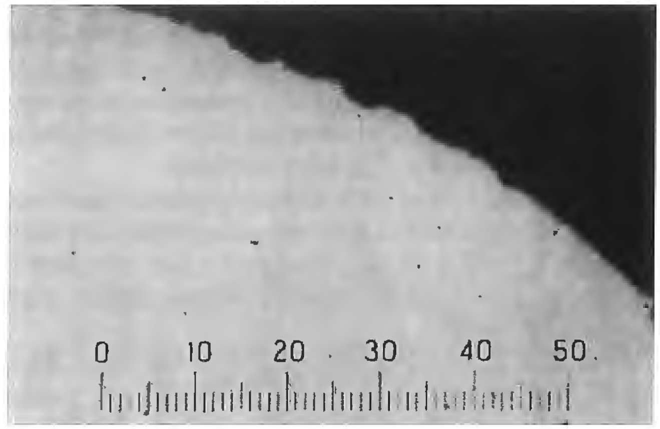
Photomicrograph 1. Sample from Photo 1.



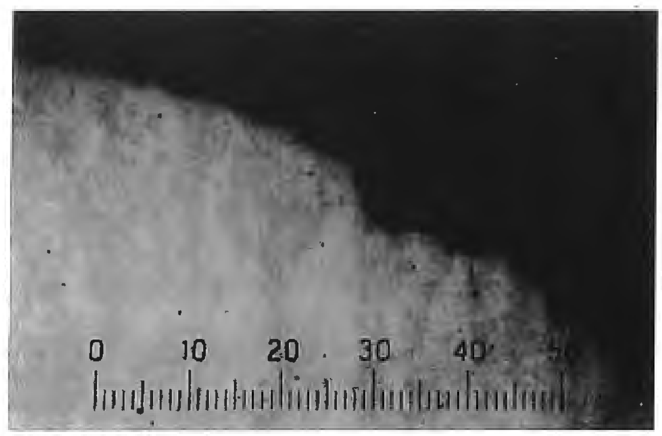
Photomicrograph 2. Sample from Photo 2.



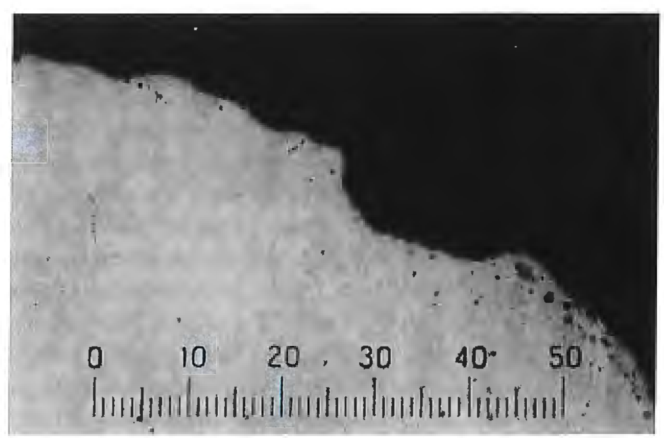
Photomicrograph 3. Sample from Photo 3.



Photomicrograph 4. Sample from Photo 4.



Photomicrograph 5. Sample from Photo 5.



Photomicrograph 6. Sample from Photo 6.

When the strand was opened by unstranding the outer wires, the center wire showed that it was not pitted. A closeup picture of the center wire after unstranding is shown in Photo 8. The center wire did not show any pitting, as shown in Photo 8A, after cleaning with the Scotch Brite pad.

These two pictures indicate that pitting due to corrosion takes place at the outer wires, which are exposed to a humid atmosphere, while the center wire is protected. A similar condition exists on portions of strand located inside the reel, which are protected by the outer layers. The outer layers get full exposure to the atmosphere and have a heavier degree of rusting compared to the inner layers.

The specimens shown in the photographs were not tested for mechanical properties. Another set of six samples of ½ in. (13 mm) diameter, 270K low-relaxation strand was prepared and exposed in a similar environment as the specimens that were photographed. All samples were cut from the same reel and were exposed uncovered in an industrial outdoor atmosphere in Jacksonville, Florida.

Samples were removed at different exposure times, such that the second set of samples has a comparable amount of rusting as shown in Photos 2 through 6. It took 19 months of exposure time to get the surface condition similar to that shown in Photo 6.

The second set of samples was tested for mechanical properties and the results are shown in Table 1. The minimum requirements for mechanical properties according to ASTM A 416 are:

Breaking strength .... 41,300 lbf (184 kN)

Load at 1 percent extension .... 37,170 lbf (165 kN)

Ultimate elongation in 24 in. (610 mm) gauge length .... 3.5 percent

Except for Sample 2, which broke with one wire fracture, all samples showed maximum breaking strength with seven wire fractures which occurred away from the grips of the tensile testing machine. This explains why Sample 2 has a slightly lower elongation value. The samples after testing are shown in Photo 10.

The differences in values between Samples 1 through 4 are within the normal variation in the testing procedure and equipment. Samples 5 and 6 showed a significant drop in breaking strength compared to Sample 1 because of excessive pitting, as shown in Photos 5 and 6 and also in Photomicrographs 5 and 6. However, the breaking strengths are high enough to meet the minimum requirement of ASTM A 416 because the loading was axial and the decrease in cross-sectional area was very small.

The effect of the degree of pitting is shown in the following tests for ductility, which are the reverse bend test and the micro-examination of the wires. One sample was picked at random from the six outer wires of each strand for these two tests.

The reverse bend test is conducted using a bend test machine. One end of the wire is clamped in the jaws, which are rounded to a radius of 0.312 in. (7.92 mm). The wire is then bent back and forth at a uniform rate through a total of 180 deg. Each 90-deg. movement in either direction is counted as one bend, and the bending operation is continued until the outer fibers fail. A guide is placed on the lever so that the wire bends on a plane at right angles to the jaws of the vise. The speed of bending is such as to avoid appreciable heating of the specimen.

This test is sometimes used as a measure of ductility or toughness of the wire, but it does not lend itself to accurate duplication of values and its use is not recommended for general application.[5] The results of the reverse bend test are shown in Table 2.

The micro-examination was done by cutting a transverse section of the outer wire. The cut specimen was then mounted and polished using standard metallographic techniques for specimen preparation. The polished section was examined under a metallographic optical microscope at a magnification of 75X, but scaled down for publication.

Photomicrographs 1 through 6 show a section of the wire circumference from samples corresponding to Photos 1 through 6. Measurable depths of pits are observed in Photomicrographs 4, 5 and 6, and the corresponding measurements are shown in Table 3. One small division of the scale imprinted on the photomicrographs is equivalent to 0.00077 in. (0.02 mm).

Based on these examinations, it can be deduced that the sample with the deepest pits will fail first when subjected to cyclic loading. The pits are stress raisers which will serve as initiation sites for fatigue failure.

The foregoing presentation and discussion show that strands which are pitted when observed by the unaided eye should be rejected. The observation must be conducted after removing the rust or the superficial iron oxide layer on the strand surface.

Several disputes in the field regarding the acceptance or rejection of prestressing strand have been settled using this method. Its adoption can eliminate much of the controversy over the acceptability of lightly rusted strand.

The contents of this paper may be reduced to a simple manual as a guide for comparing degree of rusting in prestressing strands. In order to be effective, the pictures must be reproduced clearly and accurately in color.

ACKNOWLEDGMENT

The author wishes to express his appreciation and thanks to James Barker, Ronald Dull, Michael Muckenfuss, Don Pellow and Don Pfeifer for their constructive comments; and to H. Kent Preston for his valuable comments in editing this paper.

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STRAND CHUCK MANUAL

PRESTRESS SUPPLY INC.
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PSI STRAND CHUCK MANUAL

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PSI STRAND CHUCK MANUAL

Introduction

A word about SAFETY vs. PRODUCTIVITY. Throughout this manual we stress safety first. That is the way it should be. No one wants to have someone hurt or killed on the job. Many times with a strand failure, not only is there a safety compromise but it will cost you money, too. Money lost due to extra OSHA inspections, rejected products, plant shutdowns, overtime, and increased insurance rates add up fast.

Do it right the first time! Save lives and money, too!

Chapter 1

Understanding Strand Chucks

Strand Chucks, also known as grippers, wedges, donuts, and lockoffs, are cylindrical metal devices used for gripping the prestressing cable, known as strand, while under tension. There are several strand chuck manufacturers and many different sizes. However, they all work basically the same way.

Components that make up a multiple use strand chuck include a cap, spring, retaining ring, three jaw segments and a body. The body is a round cylinder approximately 4" to 5" in length with a tapered hole through the center which allows the three jaw segments to fit inside. Each jaw segment is also tapered, the outside being smooth while the inside has many rows of little ridges known as teeth. The jaw teeth are what bite into the strand, keeping it from slipping through. The retaining ring is used to hold all three jaws together, both in and out of the chuck body. The cap and spring fit together to provide constant pressure on all three jaw segments, keeping them in line even under tension. (See diagram 1).

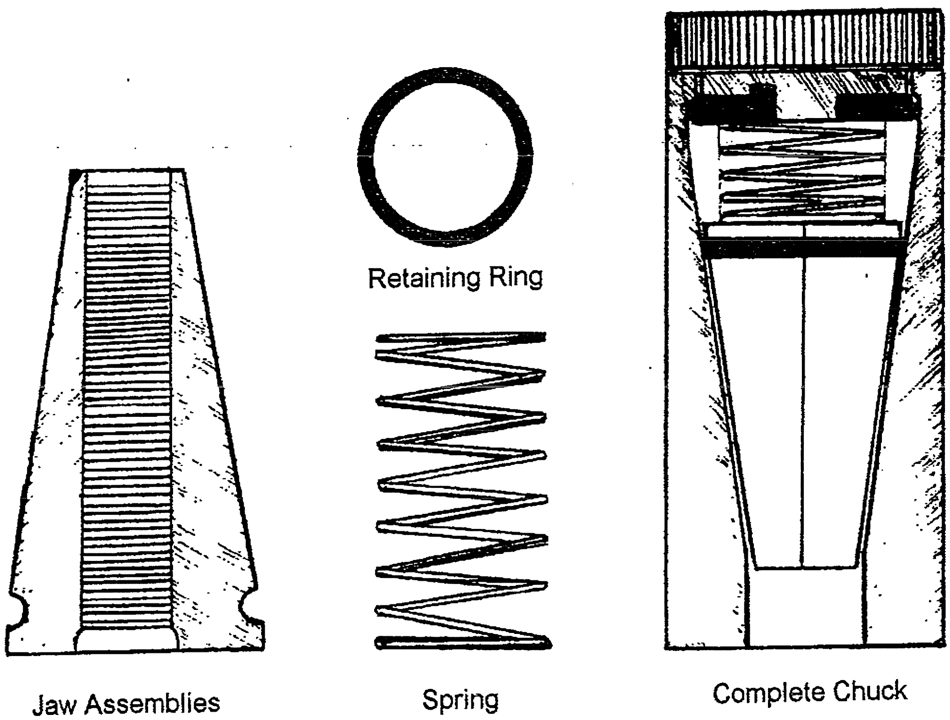


Diagram 1

How Strand Chucks Work

In prestressing, the objective is to pull the strand, stretching the cable to a predetermined load. Once the required level of tension is reached, the stressing ram releases the tension and the strand chuck takes over. The strand chuck holds the stretched strand in place without letting it slip back to its original length.

Strand chucks are used at both ends of the form, also known as a "bed". The end of the form in which the stressing jack is located is known as the "live end". The opposite end of the form is the "dead end". In some cases, as many as 70 to 80 chucks may be used on just one bed. Many times the loads placed upon strand chucks in normal use may exceed 20,000 to 40,000 pounds of force (depending upon strand size). That is enough force to cut a man in half should a strand let go or break. **At all times, safety must be the number one concern!**

All too often people ask, "It's just a chuck so why are they so expensive?" Strand chucks are manufactured using high grade steel and very detailed heat treating. Each component has to meet very fine tolerances that will enable parts **of the same size and brand** to fit together with ease year after year, yet be able to withstand the rigorous demands of prestress operations. When you are dealing with the safety of the people out in the plant, strand chucks are a small price to pay.

Chapter 2

Chuck Maintenance Room

The area in which the chucks are cleaned, inspected, lubricated, and stored is known as the "chuck maintenance area or room". The room should be large enough to handle the number of chucks necessary to run a plant on a daily operational basis. The area should be well ventilated and free of moisture and airborne contamination such as saw dust, metal dust or shavings, and any spray such as paint or form oil. Such contaminants can settle onto exposed chuck components and cause a jaw to stick or hang up. Make sure the maintenance area is efficient. Have everything set up so the chuck maintenance person can comfortably move around the area. The person should be able to go from one procedure to another without having to handle the chucks twice or move things around. (see diagram 2).

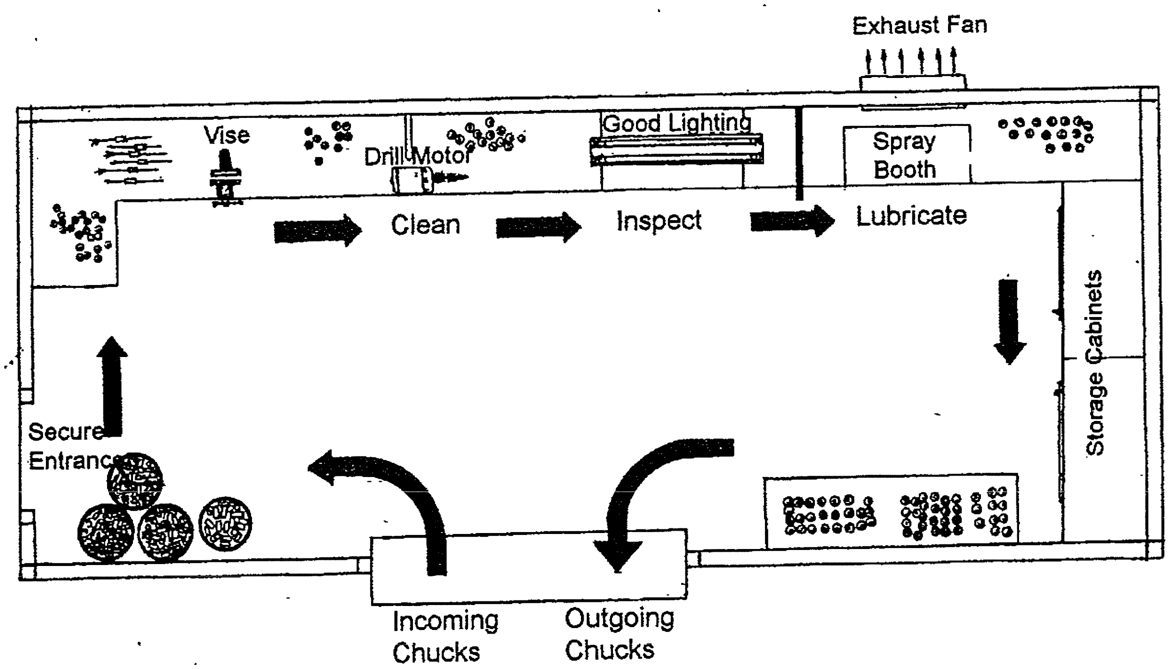


Diagram 2

The chuck maintenance area should be secure. You cannot have a successful chuck operation when unauthorized people are allowed to walk into the chuck area and walk out with a handful of chucks that may or may not be ready for use. Only allow the persons responsible for chuck maintenance to access the maintenance area. Know that every chuck that goes out the door is operationally ready.

The necessary tools needed to run a successful chuck operation are as follows: a horizontal drill motor with drill chuck, a heavy vise, at least one chuck removal tool for every size strand chuck used, one sliding hammer to use with the removal tools, and a well-lit, large workbench.

If natural ventilation is not available, an exhaust fan should be installed. Some supplies that are needed include chuck lubrication, of which there are several different types on the market that work (see Chapter 7), retaining rings for every size of jaw used, jaw and body cleaning brushes for every size of chuck used (see Chapter 6), and safety glasses which must be worn when using the jaw and body cleaning brushes.

Finding the right person to do the chuck maintenance can be challenging. This person should be willing to learn, have an understanding of **why** procedures must be followed, and take their job seriously. Not doing their job or cutting corners could get someone killed. It's better to get someone who has no prior chuck experience than hire someone who thinks they know all about chucks and is unwilling to change. Having a properly trained backup person is a good idea. Do not allow a temporary fill-in to substitute unless that person has the necessary training.

Chapter 3

Types of Chucks

The most widely used strand chuck is the multiple use chuck with cap and spring. Another type is known as a reusable anchor chuck or short bodied chuck. This has the same jaw assemblies as the longer multiple use chuck. However, the body is much shorter and the anchor chuck has no cap and spring. The anchor chuck is used primarily on the dead end of the bed (opposite from the jacking end). No load transfer takes place at the dead end, therefore, the cap and springs are not necessary. Next is the splice chuck. This chuck is used to join two pieces of strand together in the bed. The splice chuck is really two chucks in one. Two chuck bodies are combined with a screw-on coupling in the middle. Inside each chuck body is a three-piece jaw assembly identical to the jaws used in both the multiple use chuck and the anchor chuck.

NOTE: Special caution should be used when connecting splice chucks to the strand. The ends of the strand that go into the splice chuck should be cut with a cutoff saw. Do not use a torch to cut any strand that will go into a splice chuck. The heat from a torch can alter the molecular structure of the strand up to 6 inches from the cut. If torch cut strand is used in splice chucks, a strand failure could occur. The ends of the strand should also be clean and free of burrs. The strand should slide all the way in until it stops against the coupling. This is the only way to ensure the jaws will fully grip the strand. (See diagram 3). Splice chuck bodies must be screwed on to the coupler as far as the threads will allow.

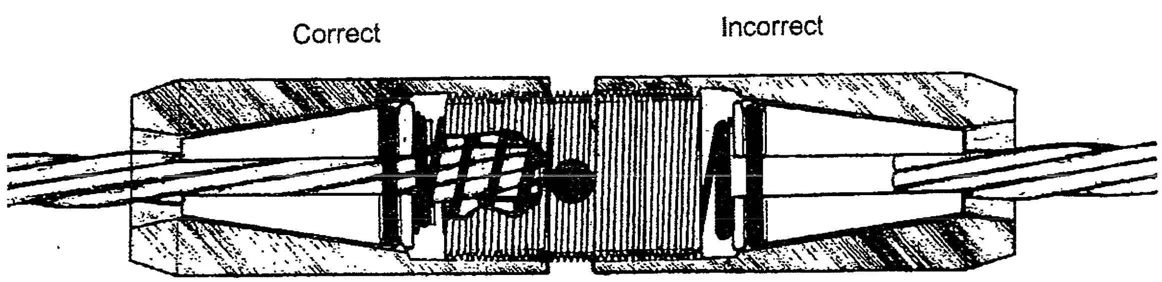


Diagram 3

Chapter 4

Stressing Systems and How They Relate to Strand Chucks

Hydraulic stressing systems known as jacks are used to grab and pull the strand. Stressing jacks consist of a pump unit or power unit and a ram. There are basically two types of rams, the center hole and the open box. The center hole ram has a special set of gripper jaws inside. When the strand is fed through the hole in the front of the ram, the gripper jaws grab hold of the strand. When hydraulic pressure is applied, the jaws start moving towards the back of the ram pulling the strand. The open box ram is open on top and has a built-in rectangular box toward the front of the ram known as the "chuck box". A regular multiple use strand chuck is slipped on to the strand. The strand chuck is then placed into the chuck box with the strand coming out the front end of the ram. When hydraulic pressure is applied, the whole chuck box with chuck moves towards the back of the ram pulling the strand. (See diagram 4). With either style ram, the gripper jaws or the strand chuck should be cleaned and inspected.

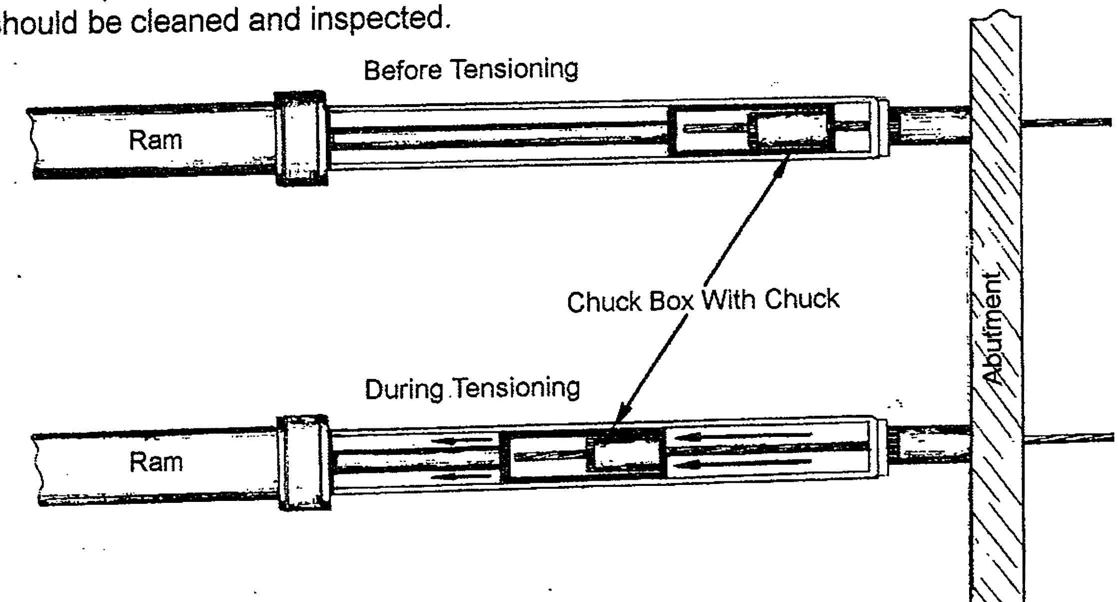


Diagram 4

When stressing, the ram must be in-line with the strand horizontally and vertically. Any off-center stressing could result in damage to your chucks or even a strand failure. (See diagram 5). The front of the ram that makes contact with the strand chucks on the form should also be inspected. Look for dents or high spots that could keep the ram from centering. Equally important are the ends of the forms known as "abutments". Usually there will be holes in the abutment for the strand to go through. The area around the holes should also be inspected for unevenness.

Some types of stressing jacks have a feature that allows the ram to slowly release the tension on the strand, gently transferring the load on to the strand chuck. By not using this ease-off feature, the load transfer is sudden and could result in damage to both the strand and the chuck. Such a shock to the strand is known as "shock loading". For best results and safety, follow the stressing jack manufacturer's recommendations. Require the jack operator to have a thorough working knowledge of the equipment and the stressing unit's manual.

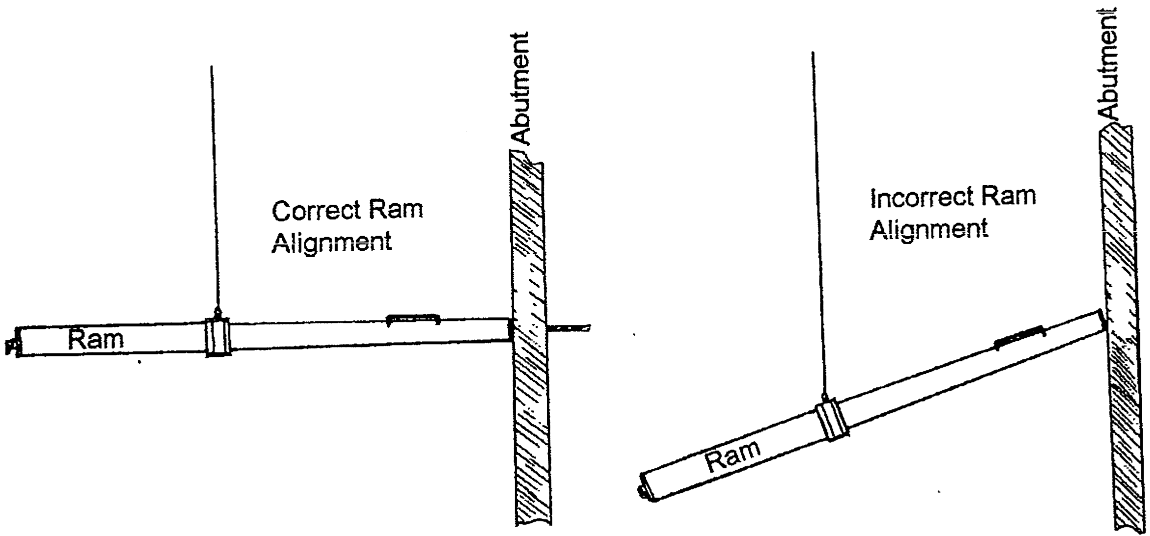


Diagram 5

Chapter 5

What To Do When Your New Chucks Arrive

When a box of strand chucks or chuck supplies arrive at your plant, where do they go? Do they go to the office or directly to the chuck room? Whoever signs for the package should first inspect the box for damage. If there is a good chance some of the contents have been lost or damaged, have the delivery person document the problem. (This could help if a claim is filed.) Once the chuck maintenance person has the box, locate the packing slip. It will be inside or attached to the outside of the box. Check the contents with the packing slip. Look for correct sizes and quantities. If there is a discrepancy, call the supplier so the order can be corrected. Now you are sure that you received what you ordered. Next, forward the packing slip to the office for processing so the bill can be paid. If the chucks or components are going to be stored, keep them in their original box (unless wet) and store them in a secure, dry place until needed. Chucks may come with a protective coating. A recommended practice is to clean and lubricate them before their initial use.

The protective coating itself is not detrimental to the performance of the chucks. Unfortunately, when some brands of chuck lubricant are applied over the existing protective coating, the combination of the two can create a putty-like substance. The buildup inside the chuck can diminish the performance and lead to excessive seating loss. If this has occurred, all contaminated jaws and bodies need to be soaked in either kerosene or mineral spirits. This will loosen and help dissolve the gummy buildup. After soaking the parts, wipe them off with a rag to remove any remaining buildup. In rare situations where the buildup has become severe, the above procedure may have to be repeated several times.

Chapter 6

Regular Chuck Cleaning

Once the strand chucks have been used, they need to be cleaned and inspected after each use. In prestress plants, there is a combination of contaminants that will interfere with the chuck's performance. Some of these include rain, dirt, dust, concrete paste, metal fragments, form oils, grease, paint, rust, and the list goes on. When contamination gets into the chucks and is left unchecked, several things can happen. The chuck may lockup on the strand requiring the use of a chuck removal tool. Contamination can also cause one or more jaw segments to hang up in the body during stressing which could lead to strand failure. Another common problem that occurs is lubricant buildup. Some chuck lubricants used over and over create an uneven layer of buildup inside the chuck body and jaws. Under a load, the jaws are riding on a rough, uneven surface inside the body causing the jaws to hang up. Any buildup in the teeth area of the jaws will diminish the gripping efficiency resulting is excessive strand slippage. (See diagram 6.)

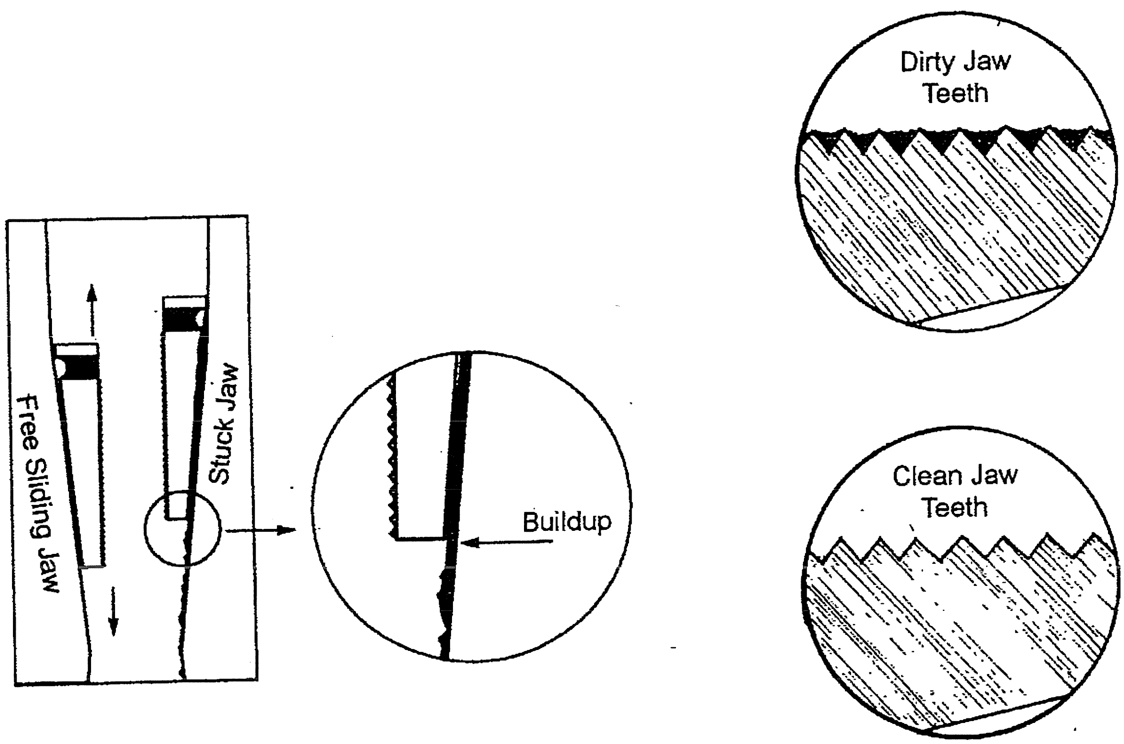


Diagram 6

Areas that need to be cleaned include the inside of the chuck body and the front and back of the jaw assemblies. Any other spots that have a noticeable buildup should also be cleaned. The most common practice involves using a horizontal drill motor and drill chuck with the body brush or jaw brush installed.

Caution: Protective eyewear should be worn. Gloves are also recommended.

With the drill motor running and up to speed, insert the strand chuck body over the body brush and gently press it against the brush. Repeat this process several times. Do not waggle the chuck body back and forth on the brush as this will damage the brush resulting in less uses. Now check inside the body. It should be smooth and free of buildup. If not, repeat the process. (See diagram 7).

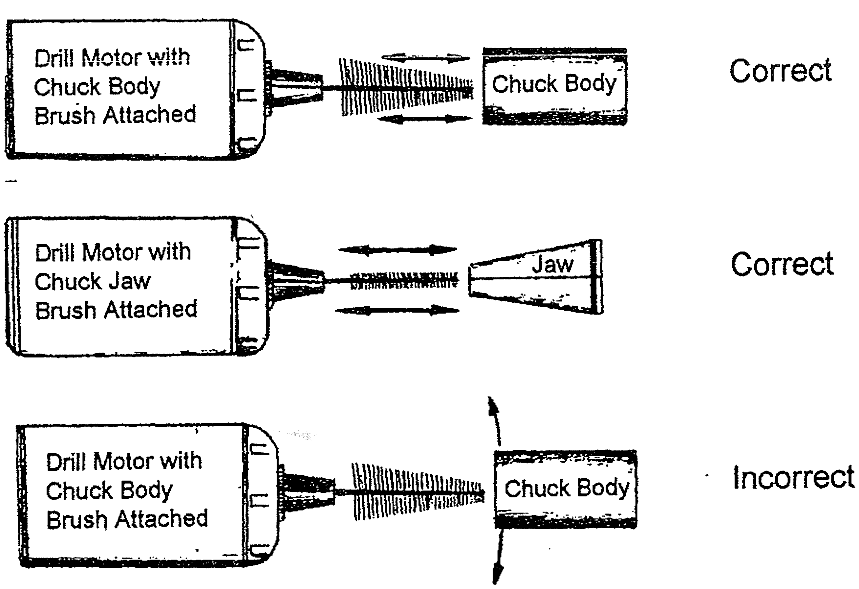


Diagram 7

When cleaning the jaw assemblies, leave the retaining ring on to keep all three jaw segments together. Use the jaw cleaning brushes in the drill motor the same way the bodies are cleaned. Now look at the teeth. Make sure the valleys between the teeth are free of buildup. Any buildup on the outside of the jaw can be wiped off with a rag and mineral spirits. (See diagram 7). **Note:** If buildup on the bodies and jaws is excessive, the pieces may have to be soaked in mineral spirits or kerosene and then wiped with rags.

Some success has been achieved by the use of industrial grade tumbling machines to clean chuck bodies and jaws. With this method, the number one rule is to use only soft, natural media such as walnut or pecan shells. Using hard man-made media such as ceramic beads will dull the jaw teeth, ruining the jaws. Bodies, caps and jaws should never be tumbled together as damage can occur.

Chapter 7

Strand Chuck Inspection

Now that the surface contamination has been cleaned off, you can see what condition your chucks and components are in. The two basic types of wear are usage wear and damage wear. Usage wear is caused by normal use like worn, dull jaws, broken or shredded retaining rings, worn chuck bodies, caps that no longer stay connected, and worn-out springs. (See diagram 8).

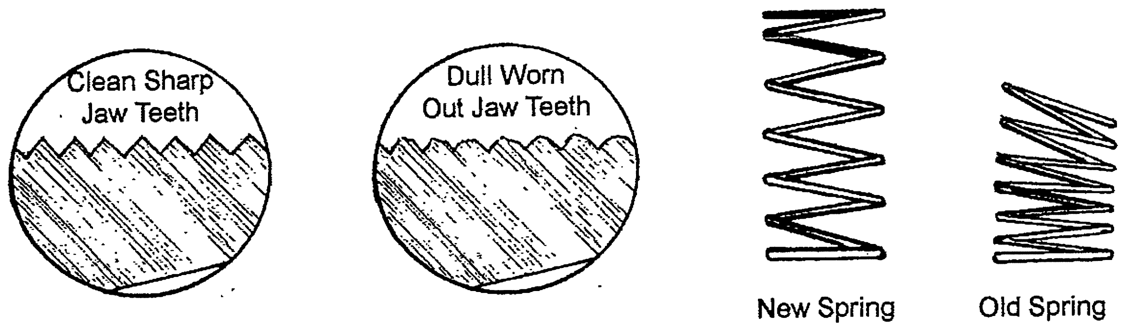
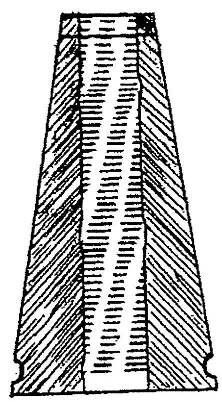


Diagram 8

The chuck body is almost perfectly round inside. When the chuck body is struck with enough force to dent it, the body can be knocked out of round. Then the next time that body is used, the chuck will lock up even worse. To free the chuck now will take even more force damaging the body further. This will continue until the chuck finally fuses to the strand and must be discarded. Another concern is safety. Any time a strand chuck is struck with enough force to dent the body, a small microscopic crack or deformation in the steel can occur. Over time and further abuse, the crack can enlarge to the point that the chuck body splits or explodes, releasing the strand causing severe injury or worse. If you see a person striking a strand chuck, that worker is compromising the safety of all who work around that bed.

Never apply heat to the strand chuck to get it to release. Concentrated heat could change the heat treating of the metal which will also make the chuck body unsafe. In the event a strand chuck is locked up on a piece of strand, cut the strand and place the chuck and the strand in a bucket and return to the chuck maintenance area for proper removal. (See Chapter 10). Other damage can show up in the jaw assemblies. Jaws that have burned through teeth (See diagram 9) have had the strand slip through the chuck with enough force to erase the teeth anywhere contact was made. Many times this is a sign of shock loading. (See Chapter 4). Other causes may include dirty jaws, contamination of the strand, or severe jaw offset. Any jaws that have missing teeth should be discarded.



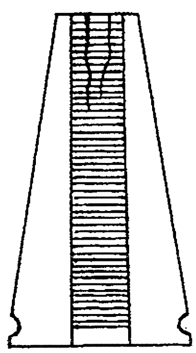
Burned Through
Jaw Segment

Diagram 9

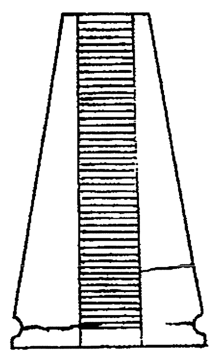
Another form of damage wear is jaw cracking. The most serious type of cracking occurs across the jaw from left to right known as transverse cracks. (See diagram 10). Some causes include improper cleaning or lubrication when one or more of the jaws hang up in the body. The uneven loading puts most of the load on just one or two jaws. Another cause is improper ram alignment. When the ram is not in-line with the strand, unequal loading takes place inside the chuck.

Improper heat treating during manufacturing could also be responsible. Should this type of cracking occur, save the jaws and call the manufacturer. Tip cracking, while not as severe, will still lessen the life expectancy of your jaws. (See diagram 10). Tip cracking is usually a sign of overstressing or a combination of several factors, including dirty or poorly lubricated chucks, a misaligned ram, a rough or uneven abutment, shock loading, and even mixing brands of chuck parts. Jaws that have small tip cracking on the thin end of the jaw many times can continue to be used. However, they should be monitored and discarded if the cracks become worse.

It is vital that the people working in the plant understand that striking a chuck with a hammer or hard object is like striking a live hand grenade.



Longitudinal
Tip Cracking



Transverse Cracking
Across The Jaw

Diagram 10

Chapter 8

Strand Chuck Lubrication

Lubrication is just as important as cleaning and inspecting. Having a thin layer of lubrication between the inner wall of the chuck body and the outer wall of the jaw assemblies will enable all three jaw segments to move efficiently up and down inside the chuck. Remember, the more efficient your chucks perform, the more uses you can expect from them. The time involved with lubricating the chucks far outweighs the time it takes to get unlubricated chucks apart.

There are several different kinds of chuck lubricants on the market that work well. Some include powdered graphite or moly-type aerosol spray and teflon sprays. The powdered graphite has been used for many years with good success. The drawback is graphite is very messy. Anything it comes in contact with turns black. Graphite is a very fine powder so the chuck maintenance person should wear some kind of OSHA approved respirator. The graphite or moly spray is also widely used. The spray is not as messy and can be applied with greater accuracy than the powder. Some drawbacks may include bad smell, long drying times, and buildup. Teflon spray is relatively new to the market. However, reports from customers have all been good. The teflon spray does not smell bad, has a faster drying time, and does not buildup like some graphite sprays do.

NOTE: Always follow the manufacturer's recommended instructions. Some lubricants require special care.

A word about drying times. All types of graphite or moly spray must be dry before reassembling the chuck. If the chuck is reassembled before the spray has dried, the lubricant can act like a glue.

Strand chucks should always be lubricated in the chuck maintenance area so the components will have a chance to dry and also to control the amount of dust and airborne contaminants that will stick to them during the drying process. At some prestress plants, the chucks are not lubricated until they are out at the form and ready to be put on the strand. This is not a recommended practice. The chucks do not have sufficient time to properly dry. They also stand a better chance of contamination by dirt, dust, etc.

When lubricating, the outside of the jaw assembly should be dusted or sprayed taking care not to expose the teeth to any lubricant. The inside of the chuck body should also be lubricated. Once dry, you should be able to place the jaw assembly into the chuck body and lightly press. Now turn the body upside down and the jaws will fall out. If the jaws do not fall out, there may be some buildup or damage that was missed or just a spot that was missed when lubricating. Once the problem is found, fix it.

Chapter 9

Stressing With The Strand Chuck

During the form setup, there are several important precautions that should be followed. The first is protecting the strand. When stringing the strand through the form, try not to let the strand lay in or drag through the mud as this can contaminate the chucks. Don't hit the strand with anything or kink the strand. Any time there is even a small nick or kink in the strand, that area could be a weak spot that could fail under a load. Be observant. Look for possible problems while the strand in being placed into the form. **AT NO TIME** should the strand be exposed to torch heat or weld splatter. Just one little bit of weld splatter hitting the strand is all it takes to change the metal structure of the strand, which in all probabilities, will fail under tension. Try to avoid strand contact with form oils. Not only could this cause chuck slippage, it could also affect the concrete adhering to the strand. Make sure no strands are crossed up in the form.

Once the strand is in place, it's time to concentrate on the ends of the form. The strands that come out of the abutments at the ends of the form should stick out far enough so the stressing ram can engage them. Before the chuck can be put on the strand, the ends of the strand should be checked for burrs and cutting torch slag. Grind anything off that would cause the chuck to hang up. Check the strand surface for contamination and wipe it off if necessary. Remember when the chuck goes on the strand, whatever was on the strand may now be in the chuck.

When placing chucks on the strand, start at the dead end (opposite of the stressing end) and slide the chuck all the way up the strand until the chuck comes in contact with the abutment. When using anchor chucks on the dead end, it may be necessary to push the jaws back up into the chuck body. (See diagram 11).

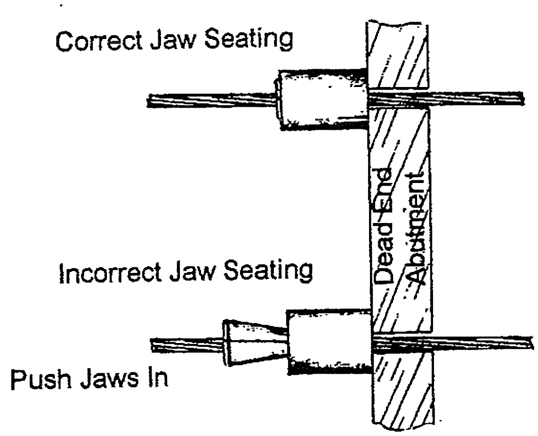


Diagram 11

Once the strand chucks are all in place, twist off the caps and make sure the jaw segments are all in line with each other. If a chuck is found with one or more jaws offset, pull the chuck off the strand. With the cap and spring in place, reset the chuck on the strand. Check the jaws again. If they continue to be offset, remove the chuck and check for any nicks, contamination, or excessive rust. If found, clean the strand off and repeat the procedure. If the jaws continue to be offset, replace the strand chuck. Now the stressing can begin. Remember to follow all the jack manufacturer's recommended instructions.

Warning: During the tensioning process, all unnecessary personnel should leave the stressing area. The persons operating the stressing jack should stay behind an approved barricade or cage. **Remember,** until the concrete is poured into that form, the bed should be treated like a loaded gun.

After the proper concrete curing has taken place, the form can be stripped. Before the concrete product can be removed, all of the strand chucks must be removed. This is known as detensioning. The most common method involves cutting the strand loose with a torch. Some forms are equipped with an open area at each end of the bed that is used when detensioning. (See diagram 12).

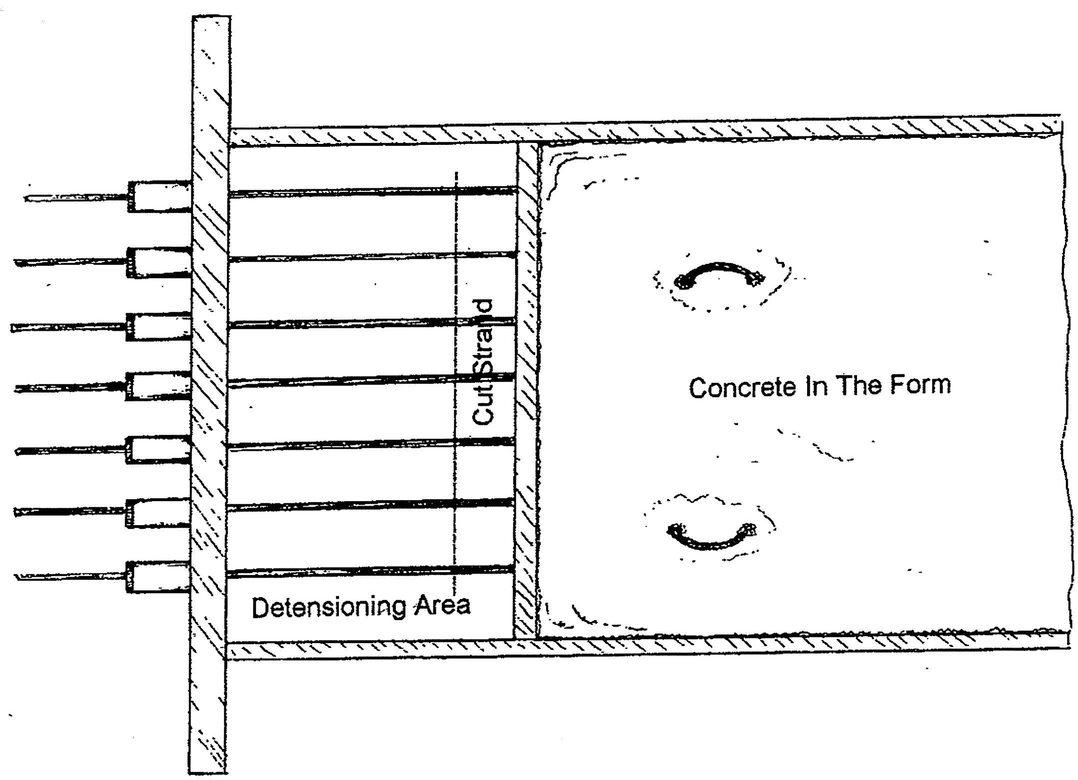


Diagram 12

The detensioning area allows the cutting torch to reach that strand located between the chuck and the concrete. The concentrated heat will cause each strand to fail right where the heat is applied, much like what will happen if weld splatter comes in contact with strand under tension.

CAUTION! The torch operator must always wear eye protection.

Once the chuck has been cut loose, remove the chuck from the scrap strand and put in a bucket or pail. Don't lay them on the ground. If the chuck is locked up on the strand, **DO NOT BEAT THE CHUCK.** Just put the chuck and the strand in the bucket and let the chuck maintenance person take care of it. **All** of the used chucks should be picked up and returned to the chuck maintenance area. Any chucks that are locked up on the strand should be placed in a vice and released using a chuck removal tool and sliding hammer. (See diagram 13).

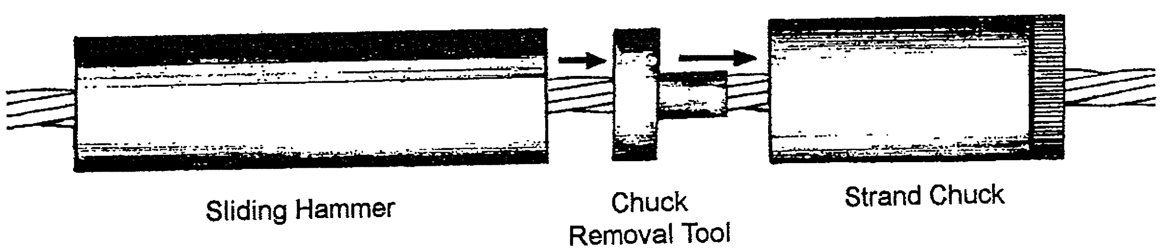


Diagram 13

Chapter 10

When To Reorder And How To Store Your Chucks

There is no chuck manufacturer out there that can accurately tell a customer how many uses they will get from a strand chuck or chuck components because of the many different variables such as the ones discussed in the previous chapters. However, it never fails that when a prestress plant runs out of something, the chuck maintenance person will try and make do by using worn-out components to get by. This is not recommended. By practicing the suggested procedures in this manual, the chuck maintenance person's job will be easier when it comes time to reorder more chucks or components. Remember, even if you place the order today, it might take up to a week before the parts are delivered. Or, they might be "out of stock". Insist on having backup supplies on hand.

With the typical strand chuck, the retaining ring has to be replaced most often so always keep a good supply of retaining rings for every size chuck used. Next are jaws. Have at least one or two dozen new jaws for each size put away in case they are needed. Remember, if the correct procedures are not followed, a set of jaws could be ruined after just one use. Have plenty of springs on hand. They don't cost that much but without the springs, the cap doesn't work. Without the cap, the chuck doesn't work. Stashing a couple of dozen complete chucks is a good idea. Should you come up short, these can be entered into service at a moment's notice. Finally, try to keep a case of lubricant and a spare box of body and jaw brushes. Remember, if you can't clean or lubricate the chucks, you can't use the chucks.

Is that big job coming to a close and you need to store the chucks? Whether short or long term storage, the chucks should be cleaned and inspected. No sense storing damaged or worn-out chucks. Cleaning them now will be a lot easier than cleaning them later.

If storage is short term, go ahead and lubricate them and store them in a secure, dry place until needed. If the storage is long term, spray the chucks with a light oil or dip them in diesel fuel. This will help control any corrosion that might occur during storage. Now, box them up and store them in a dry, secure area or cabinet. Mark each box of chucks with the chuck size and what will need to be done before the chucks can go back into service.

Example: Brand name, 1/2" Multiple Use Chucks, clean and lubricate before use.

When the next job comes up, the person responsible for getting the chucks ready will know what needs to be done.

Problems And Solutions

Question 1: Some of your chucks, jaws and caps look different from the rest of your chucks?

Answer 1: Check the brand names and numbers on the components. If they are different, you may have two brands of chucks in your inventory.

Caution: Do not mix brands of chucks or parts. Stick with only one brand of chuck.

Answer 2: You may have two different sizes mixed together. Look for size markings.

Answer 3: If the parts are the same size and brand, call the manufacturer. There may have been a design change. Make sure the parts are compatible.

Question 2: Chucks or parts are delivered with a protective wax-like coating on them. Does this need to be cleaned off?

Answer: Yes. The coating is to protect against corrosion. Simply wipe the parts off with mineral spirits and then lubricate them.

Question 3: The chuck parts don't fit together very well?

Answer 1: Make sure they are the right size and brand.

Answer 2: Check the parts for damage. If damaged parts are found, replace them!

Question 4: Retaining rings keep breaking or shredding?

Answer 1: Are you using retaining rings that are meant for strand chucks?

Answer 2: Are you using the right size retaining rings?

Answer 3: Have the retaining rings come in contact with any solvents, thinners or flammable liquids? If so, replace the retaining rings.

Answer 4: Are the insides of the chuck bodies clean and smooth? If not, reclean them and do not leave any rough or uneven areas.

Answer 5: Are the chucks properly lubricated?

Problems And Solutions (continued)

Question 5: Strand chucks keep biting through the strand?

Answer 1: Check the load being placed upon the strand.

Answer 2: Check and see if the jaws are offset in the body where one or two jaws have moved up in the body ahead of the others. If this is the case, read question #6.

Answer 3: Check the jaws for the same brand and size.

Answer 4: Is the stressing jack shock loading the chucks by releasing the strand abruptly? Always follow the manufacturer's recommended operating procedures.

Question 6: Are the jaws becoming excessively offset during tensioning?

Answer 1: Make sure the insides of the chuck bodies are clean and smooth. Look at the jaws. They should be clean and smooth on the outside and teeth should be clean and sharp on the inside.

Answer 2: Make sure the chucks have been properly lubricated with an <u>approved chuck lubricant</u> and follow the manufacturer's directions.

Answer 3: Is the nose of the ram flat and smooth with no damage that could cause the ram to be off-center?

Answer 4: Are the strand chucks bearing flat against the abutment and is the abutment flat and free of damage where the chuck makes contact?

Answer 5: Check to see if the chuck box wear plate in the ram is worn or damaged. If it is, replace it.

Question 7: Is the strand slipping out of the splice chuck?

Answer 1: Make sure both splice chuck bodies are screwed all the way on the center coupler.

Answer 2: Check the ends of the strands for burrs or slag. If present, grind the ends smooth. Also, check the strand for heavy rust or contamination, clean if necessary.

Problems And Solutions (continued)

Answer 3: Make sure the strand bottoms out. Push the strand into the splice chuck until it hits the coupling inside. This is the only way to make sure the jaws are fully engaged.

Answer 4: Check the jaws inside. Make sure they are the right size.

Question 8: Your jaws have burn-through marks on the teeth where the strand has slipped through the jaws under tension erasing the teeth where they make contact with the strand?

Answer 1: Check the strand for surface contamination and clean it off.

Answer 2: The jaws may have contamination built up in the teeth.

Answer 3: The jaws may be worn out. Check the teeth for sharpness.

Answer 4: Check the jaws for correct brand and size.

Answer 5: Shock loading the chucks can cause the jaw teeth to burn through. Always follow the recommended stressing procedures.

NOTE: Never attempt to use jaws that have burned-through teeth. These are very dangerous and could cause serious injury.

Question 9: The strand chucks do not want to come off the strand after tensioning.

Answer 1: Check the jaws and bodies. They should be clean and free of buildup.

Answer 2: Chucks should be lubricated with only approved chuck lubrication according to the manufacturer's recommendations.

Answer 3: Are the chucks being reassembled before the lubricant has dried?

Answer 4: Check the strand ends for damage. If present, replace the damaged components and discard the old parts.

Answer 5: Are the components all the same brand and size?

Question 10: The tip of your jaws are cracking?

Answer 1: Check out the jaws to see if they are damaged or worn out.

Answer 2: Are the jaws the same brand and size?

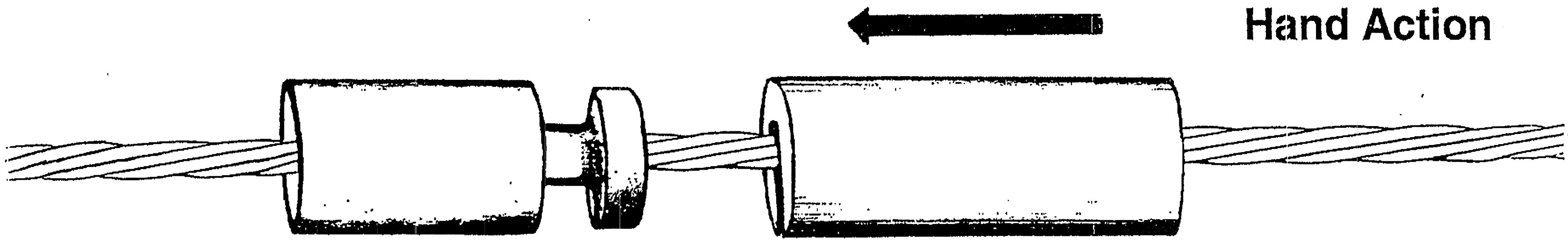
Answer 3: Are the stressing loads being placed on the strand excessive (over 80% of the ultimate strength of the strand)?

Answer 4: Are the jaws becoming excessively offset during stressing. If yes, then see question #6.

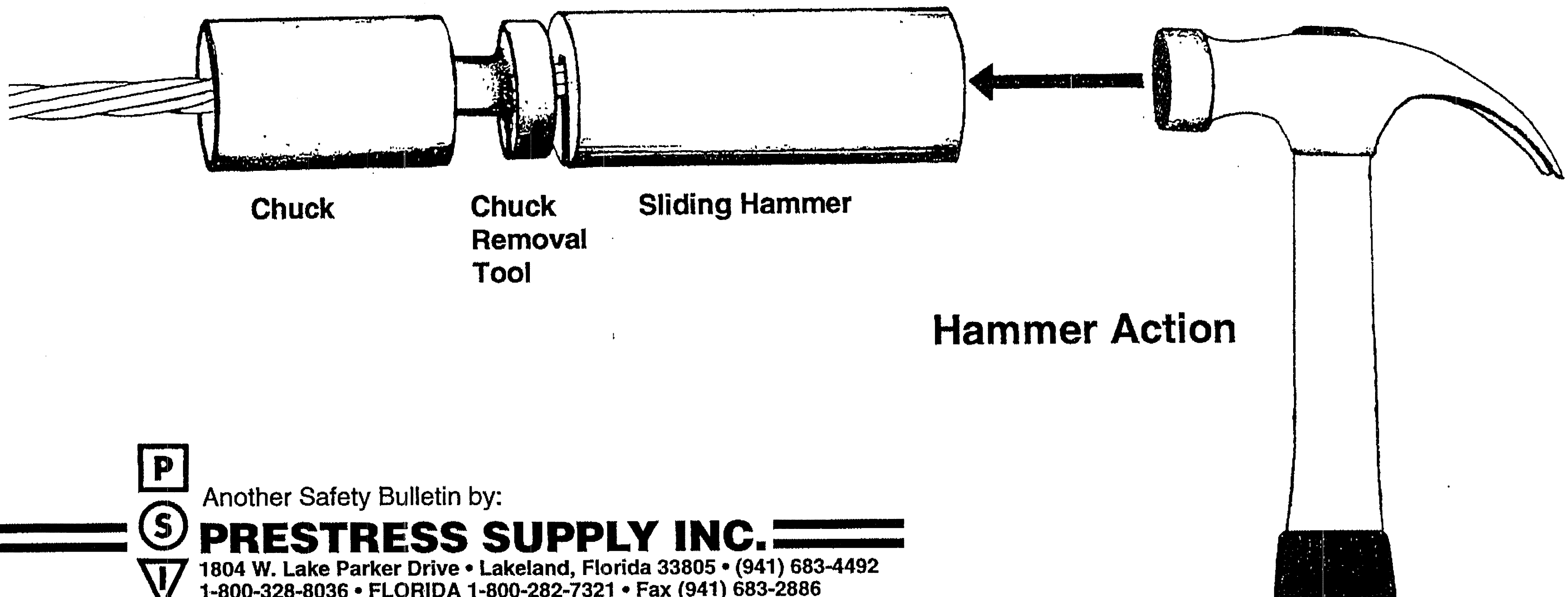
Question 11: The jaws are cracking transversely from left to right across the jaw?

Answer: Save the jaws and call the manufacturer.
Do not use jaws that have transverse cracking!

Hand Action



Use of Chuck Removal Tool: After strand has been tensioned and cut away from header, insert Chuck Removal Tool into end of chuck where jaws grip strand. Place Sliding Hammer over strand and bang into Chuck Removal Tool. If pigtail of strand is too short, use hammer on end of Sliding Hammer.



Hammer Action

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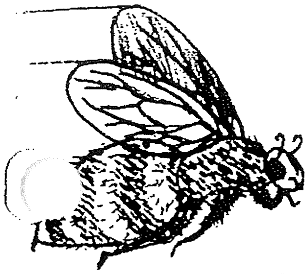
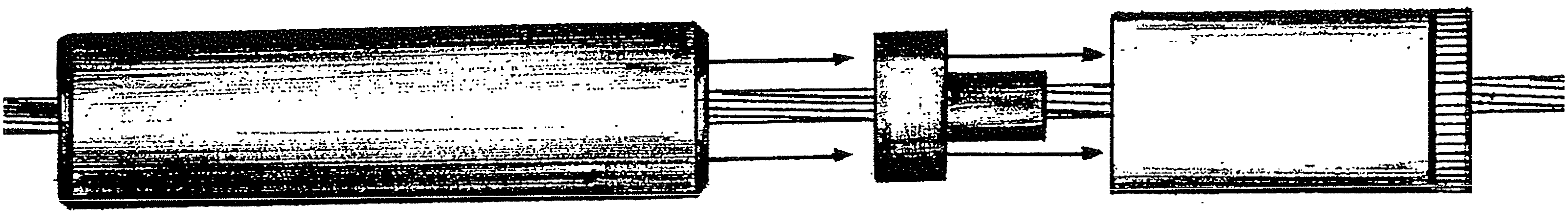


kind to your chucks ... use a chuck removal tool !



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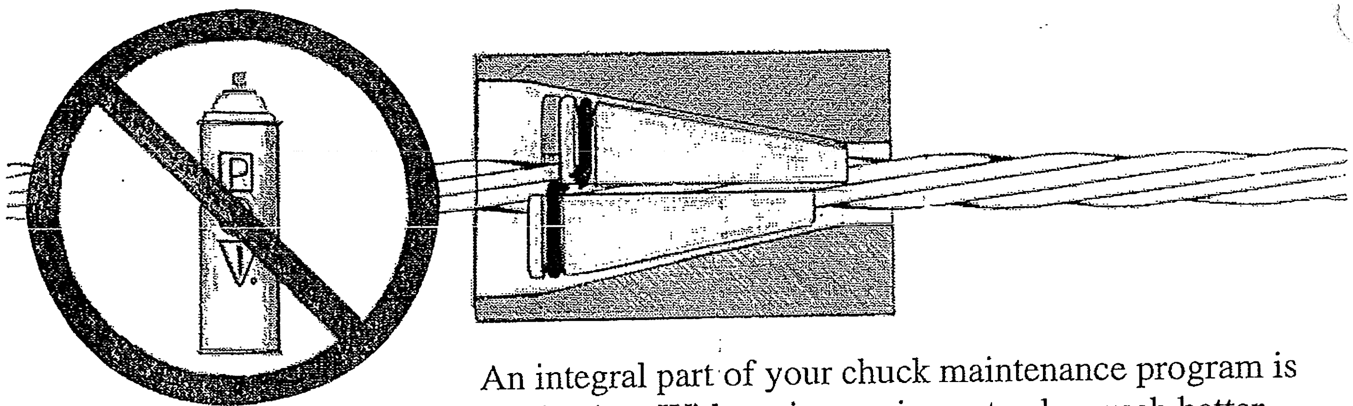
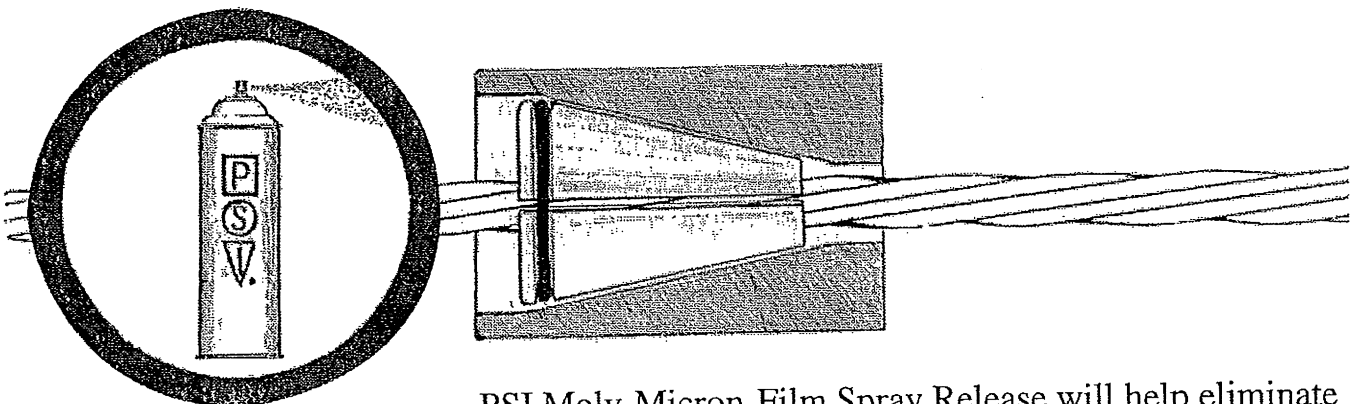
Are Your Jaws Sticking?



An integral part of your chuck maintenance program is lubrication. Without it your jaws stand a much better chance of hanging up in the barrel.



PSI Moly-Micron-Film Spray Release will help eliminate Jaws sticking and it will reduce any uneven Jaw conditions.*

*Jaws and Chuck Bodies must be thoroughly cleaned and inspected before lubrication.

Another

Safety Bulletin

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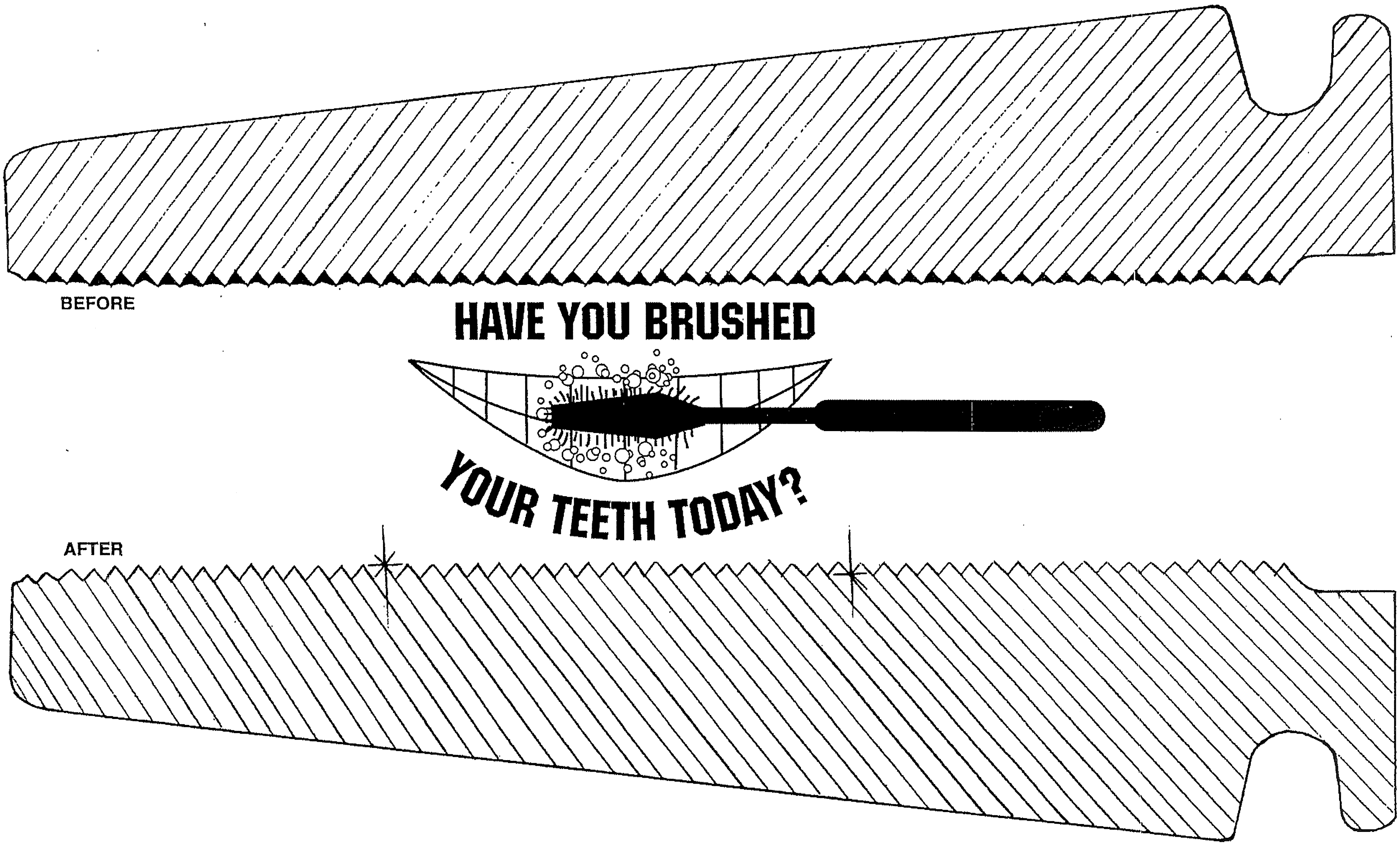
CLEANING YOUR JAW TEETH WILL INCREASE THE GRIPPING POWER OF YOUR CHUCKS!



For a complete line of strand chuck brushes and other accessories contact

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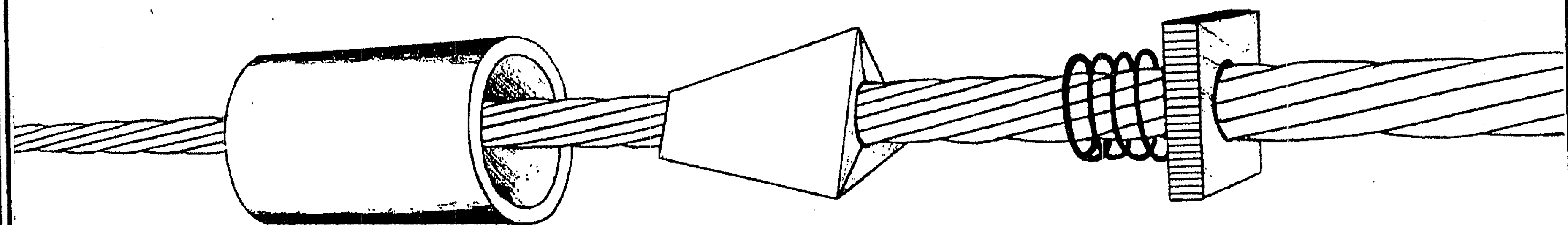
A STRAND CHUCK CAN BE VERY DANGEROUS WHEN COMPONENTS OF DIFFERENT MANUFACTURE ARE MIXED



MIXING BRAND NAME PARTS = DANGER

FOR SAFETY SAKE, **DON'T** DO IT

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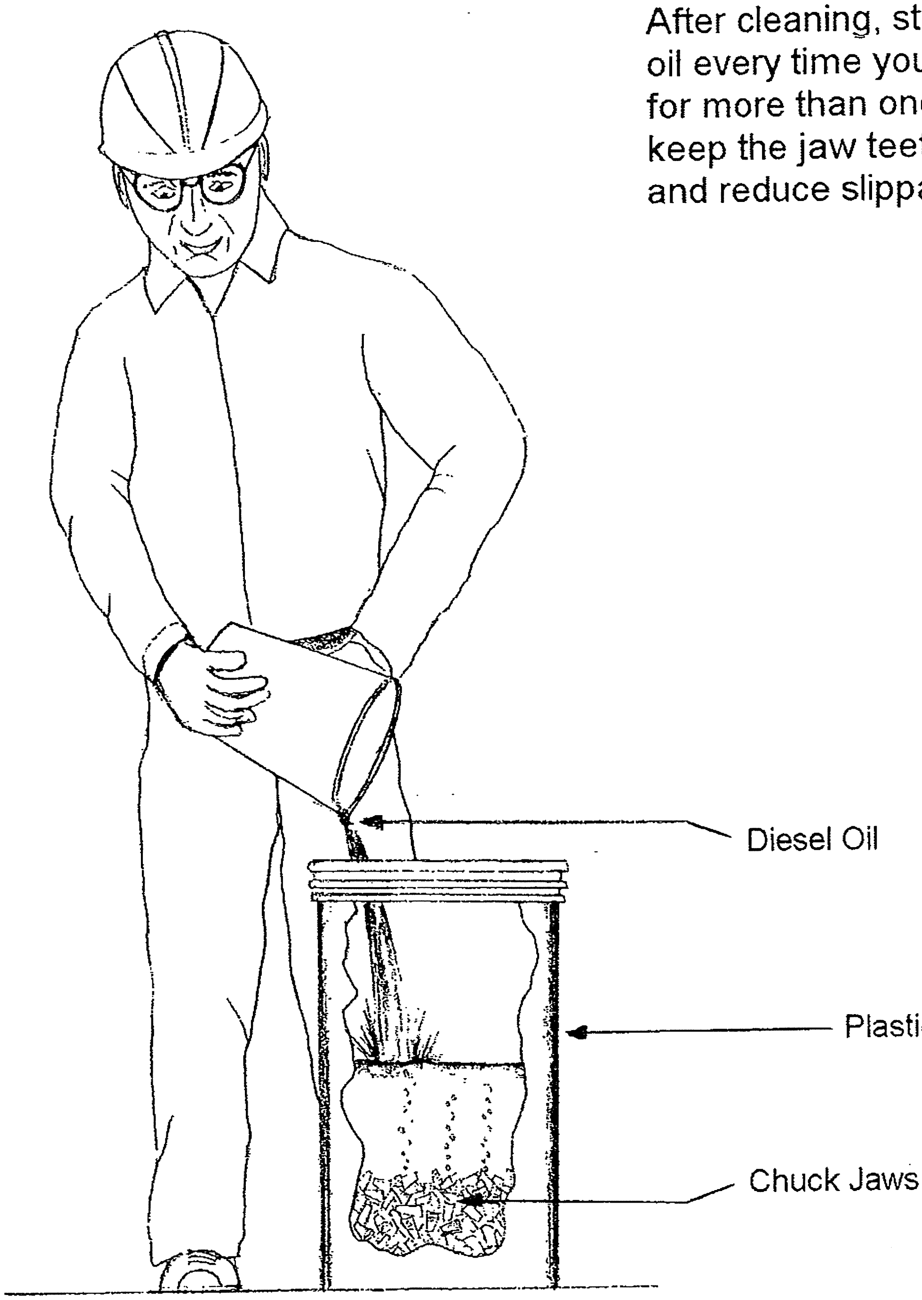
SAVE YOUR CHUCK JAWS

After cleaning, store them in diesel oil every time you do not use them for more than one week. This will keep the jaw teeth from rusting and reduce slippage.



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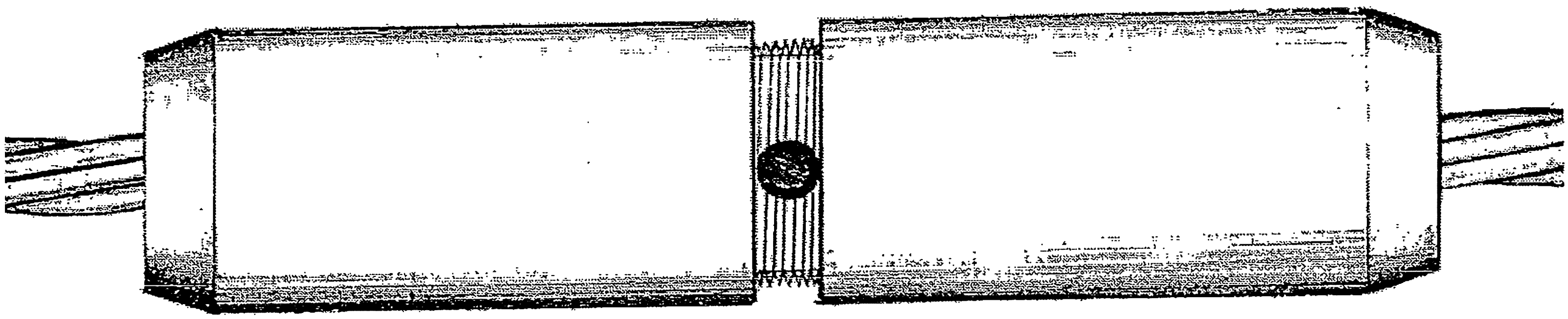
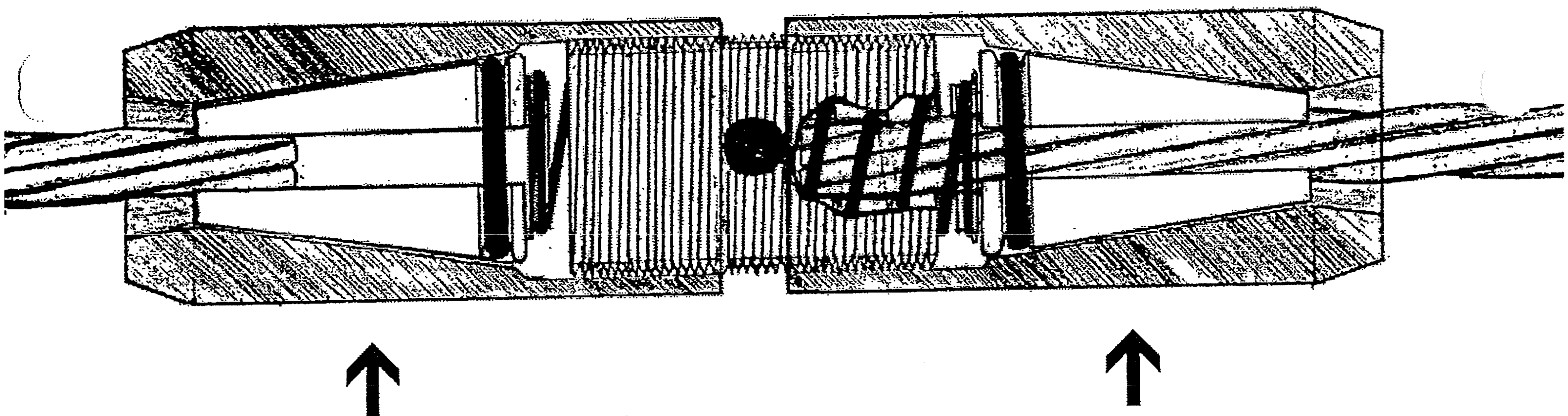
Everything Looks Good, Right?



Wrong!



Wrong **Right**

The prestressing strand must be inserted to the full depth in each side of the splice chuck coupling to be used safely.

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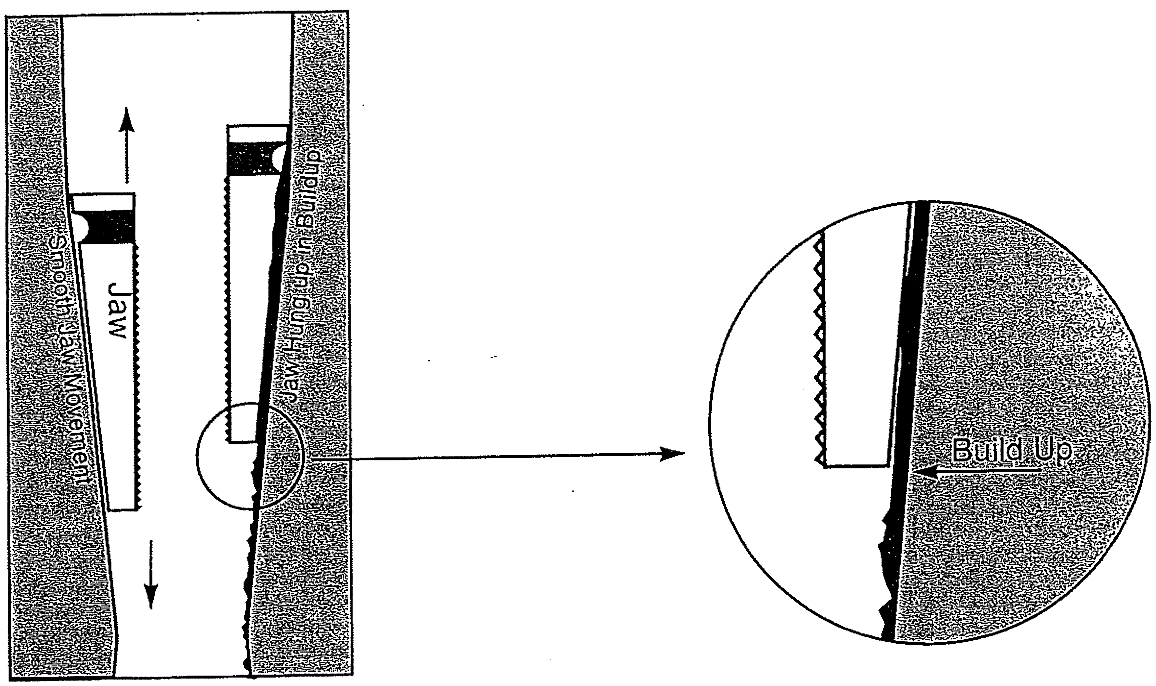
A SMOOTH MOVE!

When your strand chucks grip the strand, the jaws actually move inside the body. As your strand load is transferred through the chuck, the jaws slide up in the body, wedging the strand in place. If the inside surfaces of your chuck body are not smooth and free of debris and lubrication buildup, one or more of the jaws could get "hung up" in the body causing unequal jaw seating. This in turn could cause jaws to crack, reducing your Jaw's life and could damage the strand resulting in strand failure.



Have your chuck maintenance personnel inspect the inside of the chuck bodies for "build up" and clean it out so the bodies are smooth again and your jaws can have a "Smooth Move".

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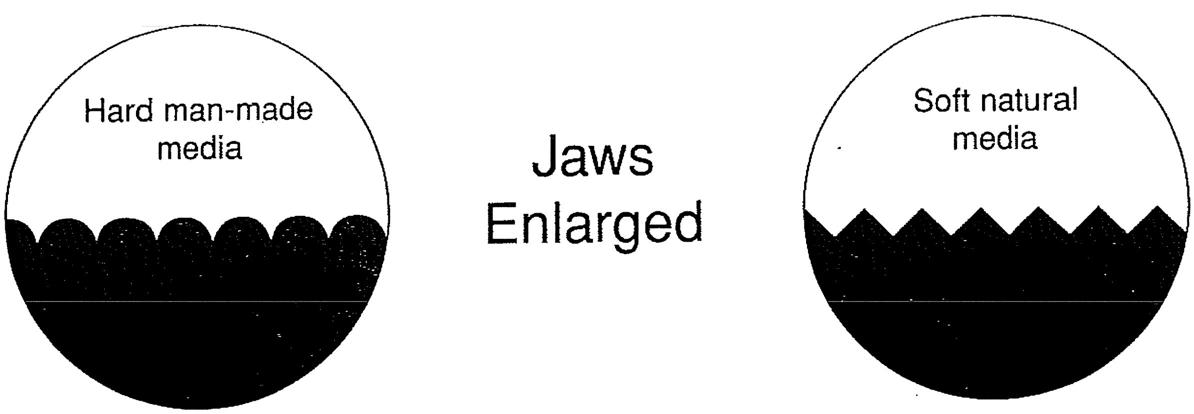
TUMBLING CAN BE HAZARDOUS TO YOUR JAWS HEALTH!

UNLESS you use natural tumbling media such as pecan or walnut shell. Tumbling with hard man-made media like ceramic beads will wear your teeth down greatly reducing your ability to grip the strand.



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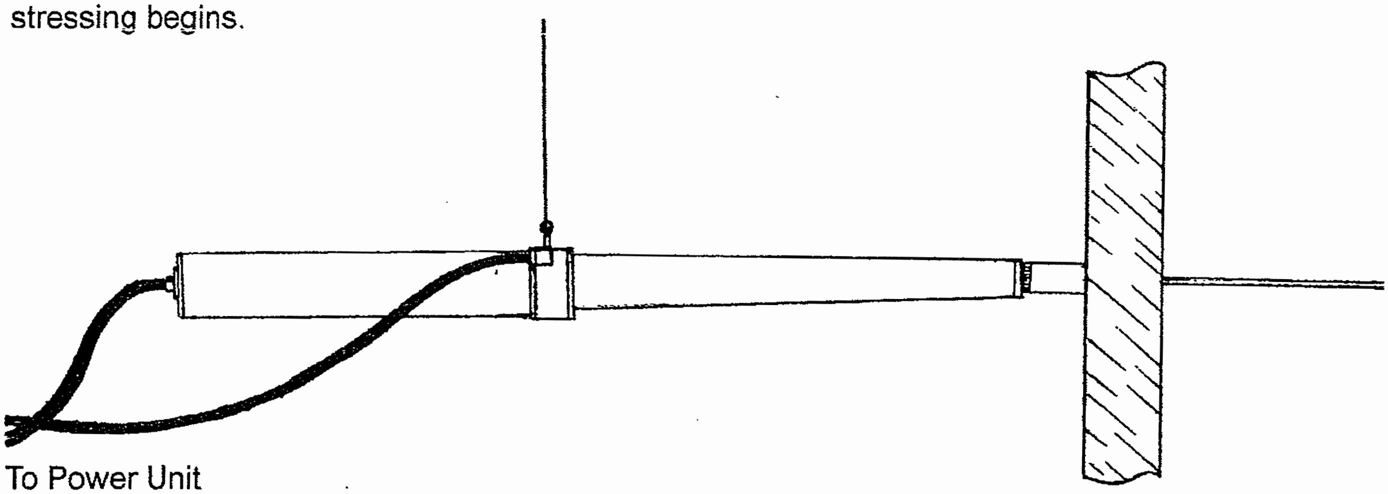
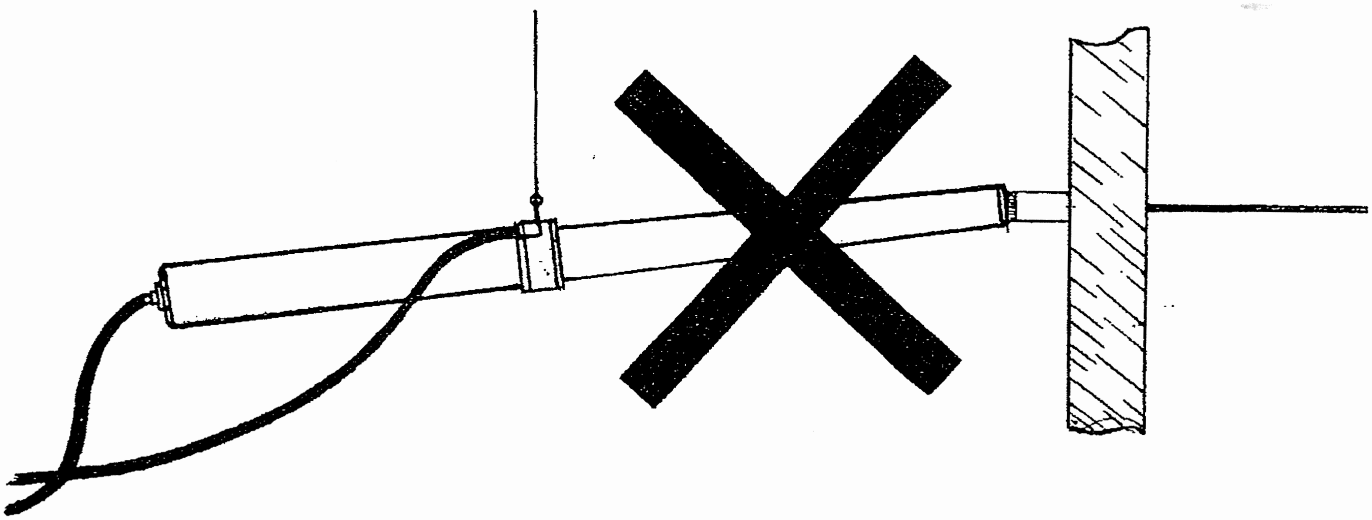
Ram Centering

Allowing the ram to center itself is detrimental to the performance of your strand chucks. During the time it takes for a ram to become centered during stressing, your jaws inside the chucks are having an unequal force put upon them. The uneven loading can cause offset jaw alignment, jaw cracking, excessive seating loss and even strand failure. Ram alignment should be obtained before stressing begins.



To Power Unit



To Power Unit

If in doubt use a level and check your form and stressing plate then check your ram, both should be at a 90° angle. Left and right alignment should also be checked.

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