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Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns

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Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns

prepared by

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CHAPTER 1 — INTRODUCTION

1. Purpose

This report is a catalogue of cracks which can occur in either precast or prestressed concrete beams and columns during casting, stripping or shipment of the product. An earlier report dealt with fabrication and shipment cracks in prestressed hollow-core and double-tee products.* Some cracks can and do occur under service load, but this report is concerned with the fabrication and shipment process.

This report is intended to serve as a guide to identify typical cracks occurring in production and shipping of beams and columns. The report can be utilized by the plant or production manager and quality control supervisor to identify casting, stripping or shipping cracks which can originate from numerous sources.

The plant engineer can employ the report to ascertain whether cracks are of a design or fabrication origin. The production manager will find suggestions as to fabrication techniques which will help to prevent cracking. Lastly, the designer can utilize the report to help determine the causes and consequences of cracks and to assist in making a judgment as to the acceptability of the products.

2. How the Report Was Developed

The report is based on a questionnaire distributed to Producer Members of the Prestressed Concrete Institute (PCI) who manufacture precast beams and columns.

The questionnaire depicted different types of cracks and requested each respondent to list the probable causes, prevention, effect on serviceability and suggested repair methods. The replies were then synthesized by the Committee into this report.

3. How the Report Is Structured

The report is divided into two sections: Cracks in Beams and Cracks in Columns. Each crack is listed numerically and is given a generic name relative to its position and direction of propagation in the member. Some cracks are further subdivided with reference to their location within the member. A brief description of the crack appears under the title.

The body of the report deals with the causes, prevention, effect and repair of the cracks. In the first column, the causes are described with an explanation, where appropriate. If a particular cause applies only to a crack in a certain location in the member, it is noted. For each cause listed, possible preventive measures are given in the second column. The last two columns cover consequences of the cracks and suggested methods of repair when required.

Daps, blockouts, and notches are not covered in this report. These are special situations and in many cases they will require confining reinforcement to function properly.

The report covers all types of beams, including rectangular sections, L-shaped sections, inverted tee beams, and I girders. Where an item specifically applies to one type of cross section, it is noted.

4. Word of Caution

The designer or plant engineer should be made aware of any cracks which oc-

*Refer to PCI JOURNAL, V. 28, No. 1, January-February 1983, pp. 18-39.

cur in order to be sure that the intended use of the member is not affected. This report has listed the typical causes, preventions, and repairs of cracks, but it cannot be expected to anticipate every possible situation and variation in requirements for design and serviceability. It should also be noted that there may be other causes, possible preventive measures, and acceptable repair procedures in addition to those listed in the report.

Evaluation by a qualified inspector should always be required. The reader is also referred to the *PCI Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products*, PCI MNL-116, for a thorough description of proper production and repair techniques.

Members which will be exposed to a corrosive environment are a special case; their integrity must be reviewed in this context. Epoxy can be utilized to repair and seal the visual cracks as required, even though they are determined not to affect the structural integrity of the member.

The following publications of the American Concrete Institute will provide guidance in the use of epoxy compounds:

- ACI 503R — "Use of Epoxy Compounds With Concrete."
- ACI 503.1 — "Standard Specifications for Bonding Hardened Concrete, Steel, Wood, Brick and Other Materials to Hardened Concrete with a Multi-Component Epoxy Adhesive."
- ACI 503.2 — "Standard Specification for Bonding Plastic Concrete to Hardened Concrete With a Multi-Component Epoxy Adhesive."
- ACI 503.4 — "Standard Specification for Repairing Concrete With Epoxy Mortars."

CHAPTER 2 — DEFINITIONS

Anneal: Heat strands prior to cutting to effect slower application of prestress.

Blocking: See Dunnage.

Bulkheads: See Header.

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

Corbel: A projection from the precast member designed to resist vertical and horizontal forces as required.

Corrosive Environment: Any prolonged exposure to weather, water or chemicals, either by direct contact or through the atmosphere, that will promote corrosion in reinforcement.

Crack: A visible separation at the surface of the concrete.

Debond: Any method used to prevent bond between reinforcement and concrete.

Detensioning: See "Transfer."

Drape: Method whereby a straight strand is deflected to modify prestress eccentricity.

Dunnage: Shoring on which precast member is stored.

Flange: The wider portion of a beam cross section. Typically, bottom flanges provide a bearing ledge for other members.

Hairline Crack: A separation in the mass of the concrete with a displacement measuring less than 0.004 in. (0.1 mm).

Harp: See Drape.

Haunch: See Corbel.

Heel: The horizontal bottom surface at the end of the member.

Header: The end form of a precast member, sometimes called a bulkhead.

Hold-Down Device: A mechanism used to tie down draped strand.

Ledge: A continuous corbel on a beam.

Masking: Placing a sheath around

the strand to prevent bonding of concrete.

Pallet: A separate piece of formwork for the bottom surface of a member.

Preset Time: Initial setting of concrete prior to applying elevated curing temperatures.

Release: Detensioning of prestressed strand. Also refers to the strength of the concrete when detensioning occurs ("release strength").

Spall: A portion of concrete broken away from the mass.

Strongback: Any device attached to a member to increase its stiffness.

Transfer: Act of transferring stress in prestressing tendons from jacks on pretensioning bed to concrete member. Also refers to the strength of the concrete when the transfer occurs.

Web: The narrow portion of a beam cross section.

NOTE: A series of tables, depicting various types of cracking, causes, preventive measures, effects on serviceability, and possible repair procedures, begins on the following page.

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, or 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. 1. Inadequate top reinforcement. 2. Incorrect top reinforcement or incorrect placement of top reinforcement. 3. Low release strength. 4. Lack of strand debonding at end of beam (Crack 1a).	A. Reduce top fiber tension. 1. Proper design of top steel for stresses (see latest edition of ACI 318 — Chapter 18 or AASHTO, Div. 1, Sect. 6). 2. Improve inspection prior to concrete placement and correct for subsequent casts. 3. Increase release strength. 4. Base debonding on stress limitations of section and use inspection prior to concrete placement to confirm specified debonding.	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, location, and size of cracks.	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.

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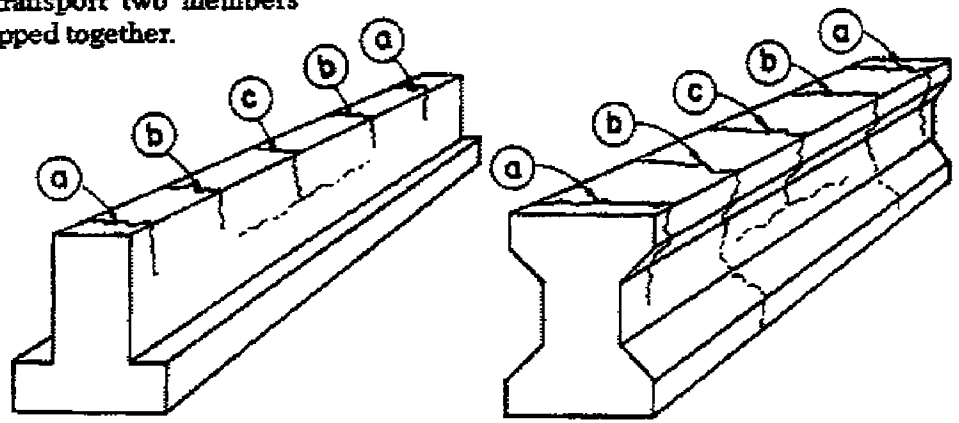
1. Transverse Crack at Top of Beam (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
A. (cont.) 5. Improper location of lifting or dunnage points (Cracks 1b and 1c).	A. (cont.) 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.	If the crack extends horizontally (as shown by the dashed line in the figure for Crack 1c) the condition may be severe, and evaluation by an engineer is mandatory.	
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.		

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

CAUSE	PREVENTION	EFFECT	REPAIR
D. Form expansion with curing temperature rise if preset time is inadequate (Crack 1a). E. Excessive side fiber tension (Crack 1b). 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.	D. Lengthen preset time — Determine in accordance with ASTM C403. E. Reduce side fiber tension. 1. Provide lateral strongbacks or transport two members strapped together.		



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 stripping and handling. 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.	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.	If the plane of the crack does not coincide with 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 or coating should be considered.

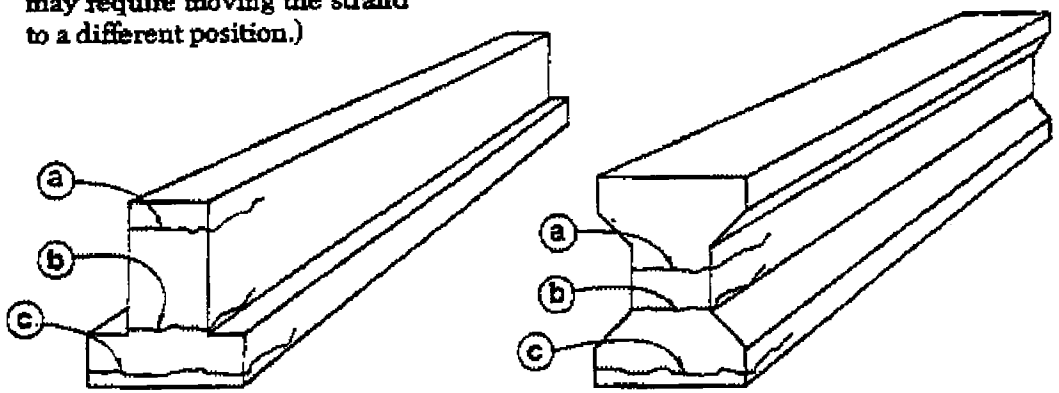
2. Horizontal End Crack in Web or Flange (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
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.	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. Settlement of concrete under a concentration of reinforcement near the top of the beam (Crack 2a).	E. 1. Use sufficient vibration. 2. Allow time for initial settlement and revibrate the concrete. 3. Reduce maximum aggregate size in the concrete mix.		

(continued on next page)

2. Horizontal End Crack in Web or Flange (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
F. Differential stresses between web and flange during detensioning, or inherent in the design (Crack 2b).	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. Insufficient cover over the bottom row of strands (Crack 2c).	G. Provide sufficient cover. (This may require moving the strand to a different position.)		



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 — This 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 in the figure.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper production. 1. Indentations or joint offsets in forms. 2. Binding in forms. 3. Bottom plate at end of member anchored or restrained in form (Crack 3a). 4. Improper end curing (Crack 3a). B. Incorrect reinforcement. 1. Inadequate reinforcement.	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. 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.	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 crack. 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.	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.

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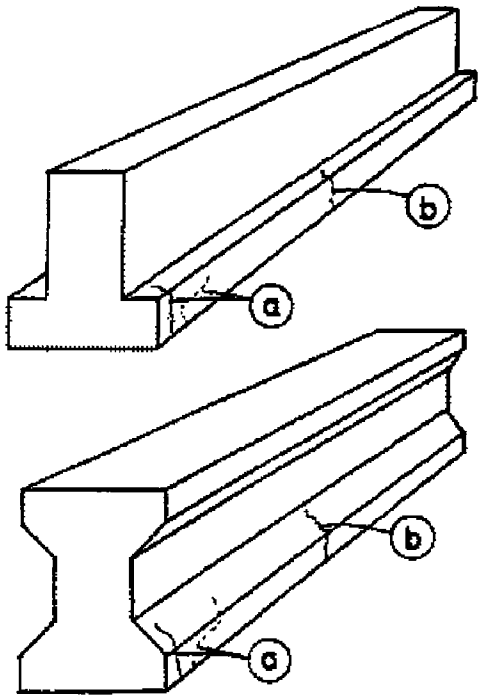
3. Vertical and Diagonal Cracks at Bottom of Member (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
B. (cont.) 2. Incorrect placement of reinforcement.	B. (cont.) 2. Place reinforcement in its specified location and use inspection prior to concrete placement to confirm reinforcement details.	If strand 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.	
3. Improper strand tensioning.	3. Compare measured strand elongation versus computed elongation.		
4. Prestress losses underestimated.	4. Recompute losses.		
C. Bond failure of strands at end of member.	C. Prevent bond failures.		
1. Foreign matter on strands.	1. Keep strands clean.		
2. Insufficient vibration.	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.		

3. Vertical and Diagonal Cracks at Bottom of Member (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
E. Improper release. 1. Low release strength. 2. Improper procedure for detensioning strands (Crack 3a). 3. Improper detensioning sequence (Crack 3a). 4. Improperly masked strand (Crack 3a). F. Improper storage or handling of members designed to be cantilevered (Crack 3b).	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 debonding on stress limitations of section and use inspection prior to concrete placement to confirm specified debonding. Provide confining reinforcement around masked strands. Strands located near the side face should not be debonded unless absolutely necessary. F. Lift and support cantilever members as close to bearing points as possible.		

3a Located near the end of the member

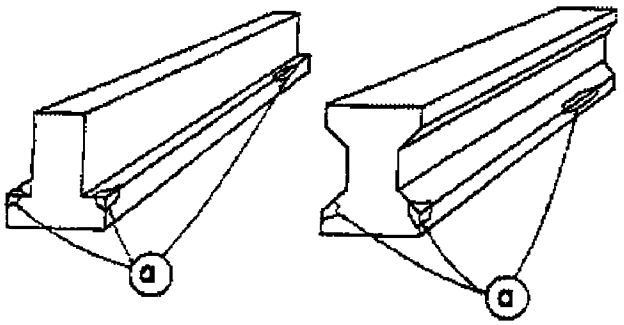
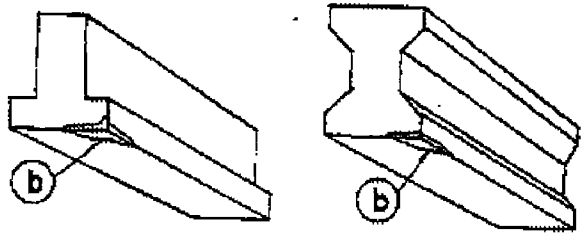
3b Located near the center of the member

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).	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.	For cracks in the top of the flange, if there is not a member bearing on the ledge in the vicinity of 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 non-bearing areas require only cosmetic patching. In bearing conditions with adequate reinforcement the bearing 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.

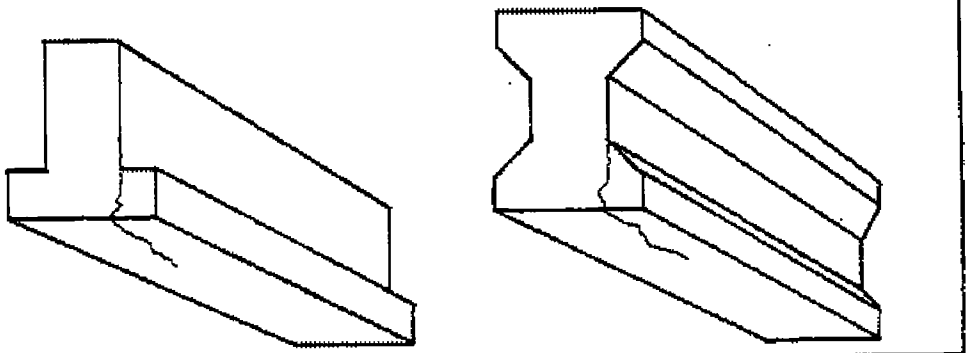
4. Ledge Corner Crack (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
B. (cont.) 5. Improperly masked strands. C. Improper release. 1. Improper detensioning sequence. 2. Binding in form during detensioning.	B. (cont.) 5. Base debonding on stress limitations of section and use inspection prior to concrete placement to confirm specified debonding. Provide confining reinforcement 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 detensioning. 2. Keep forms properly oiled and in good repair.	 4a Located at top of ledge  4b Located 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 sequence. B. 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 reinforcement is being used and use inspection prior to concrete placement to confirm reinforcement 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 sufficient 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. 3. Heat applied too early in the curing cycle. 4. Excessive curing temperatures. B. Settlement of concrete around top reinforcement (subsidence).	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. 3. Lengthen preset time. Determine in accordance with ASTM C403. 4. Reduce curing temperatures. B. Allow time for initial settlement and revibrate the concrete.	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.

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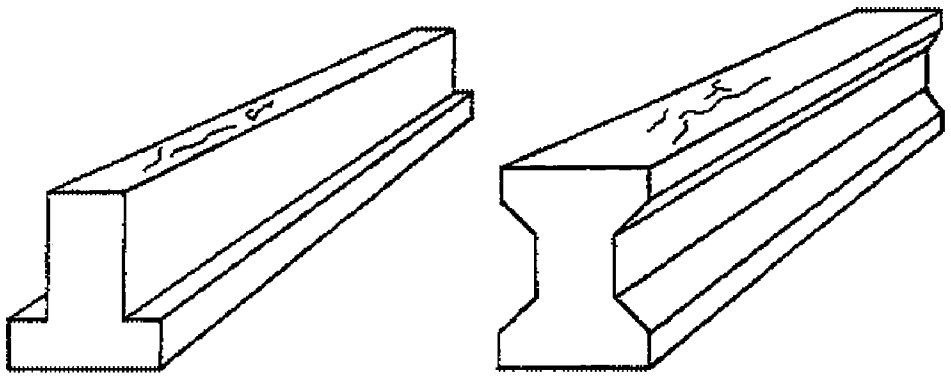
6. Miscellaneous Cracks (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
C. Insufficient vibration.	C. Use sufficient vibration to eliminate voids under top reinforcement.		

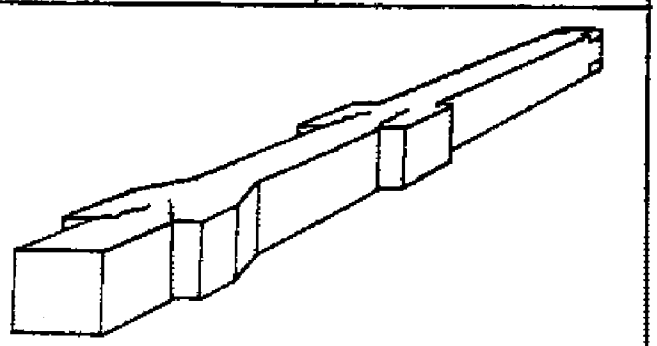


CHAPTER 4 — CRACKS IN COLUMNS

1. Interior Corner Crack in Corbel

Description — Crack is located at the interior corner of the corbel and may extend into column at an angle.

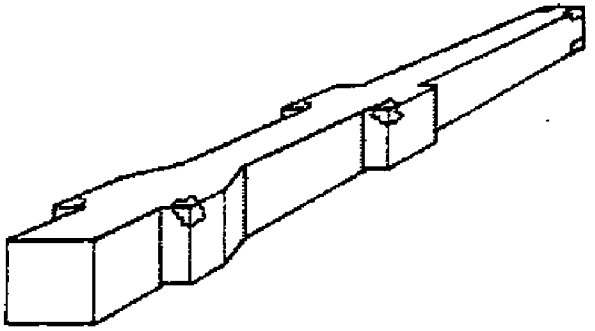
CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper production. 1. Indentation of forms. 2. Binding in forms. 3. Improper procedure for detensioning. B. Improper handling and storage. 1. Uneven dunnage. 2. Bumping member. C. Form expansion with curing temperature rise if preset time is inadequate.	A. Improve production methods. 1. Keep forms in good repair. 2. Keep forms clean and properly oiled. 3. Release corbel forms prior to detensioning. Detension at both ends of member simultaneously by annealing. B. Improve handling and storage techniques. 1. Keep dunnage clear of corbel. 2. Allow adequate clearance while handling. C. Lengthen preset time — Determine in accordance with ASTM C403.	Probably no effect if there has been no displacement; however, such displacement may not be apparent until the corbel is loaded. Must be repaired if member is exposed to a corrosive environment.	If required, inject with epoxy.



2. Exterior Corner Crack or Spall in Corbel

Description — Crack is located at the exterior corner of the corbel and usually occurs just beyond the principal tensile reinforcement.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper production. 1. Indentation in forms. 2. Binding in forms. 3. Improper position of reinforcement. B. Form expansion with curing temperature rise if preset time is inadequate. C. Improper handling and storage. 1. Uneven dunnage. 2. Bumping member. D. Improper procedure for detensioning.	A. Improve production methods. 1. Keep forms in good repair. 2. Keep forms clean and properly oiled. 3. Properly fabricate, position and secure reinforcement. Use inspection prior to concrete placement to confirm reinforcement details. B. Lengthen preset time — Determine in accordance with ASTM C403. C. Improve handling and storage techniques. 1. Keep dunnage clear of corbel. 2. Allow adequate clearance while handling. D. Release corbel forms prior to detensioning. Detension at both ends of member simultaneously by annealing.	Could be severe if crack extends into the bearing area. Usually repairable.	If piece is not fragmented, repair with epoxy. Otherwise, remold with integral patch.



3. Horizontal Crack

Description — Crack is horizontal often lining up with stirrups. May extend completely around member.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper handling. 1. Misplacement of lifting devices. 2. Too long a span or cantilever during storage. 3. Uneven dunnage when more than two support points are used.	A. Adopt proper handling techniques. 1. Locate lifting devices to minimize bending stresses. 2. Check bending stresses induced by storage methods. 3. Check elevation and bearing capacity of dunnage.	If crack widths are small, there is no detrimental effect. Unless column is exposed to a corrosive environment, repair is not necessary.	If required, inject with epoxy or patch with grout.
B. Improper production. 1. Indentation in forms. 2. Binding in forms. 3. Joint offset in forms.	B. Improve production methods. 1. Keep forms in good repair. 2. Keep forms clean and properly oiled. 3. Fabricate forms with even joints.		
C. Corbel restrained in forms.	C. Eliminate or reduce restraint of corbel in forms.		
D. Form expansion with curing temperature rise if preset time is inadequate.	D. Lengthen preset time — Determine in accordance with ASTM C403.		

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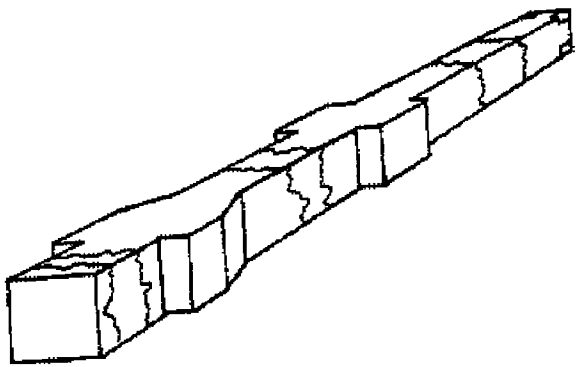
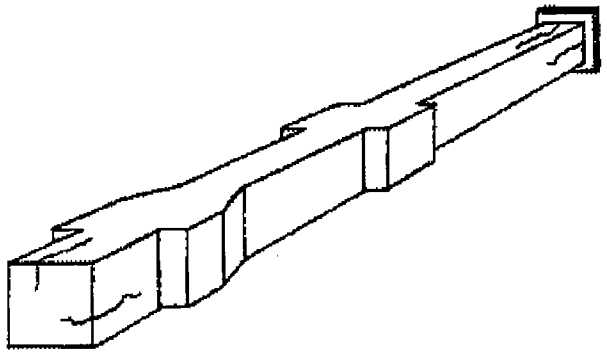
3. Horizontal Crack (cont.)

CAUSE	PREVENTION	EFFECT	REPAIR
E. Shrinkage. 1. Excess water in concrete. 2. Rapid moisture loss. 3. Heat applied too early in the curing cycle. 4. Excessive curing temperatures.	E. Proper mix and curing. 1. Reduce water in concrete. 2. Cover product completely and as soon as possible (especially in windy, hot or dry exposures). If necessary, spray product with water mist or curing compound before covering. Use retarding admixture. 3. Lengthen preset time — Determine in accordance with ASTM C403. 4. Reduce curing temperatures.		

4. Vertical Crack at Ends

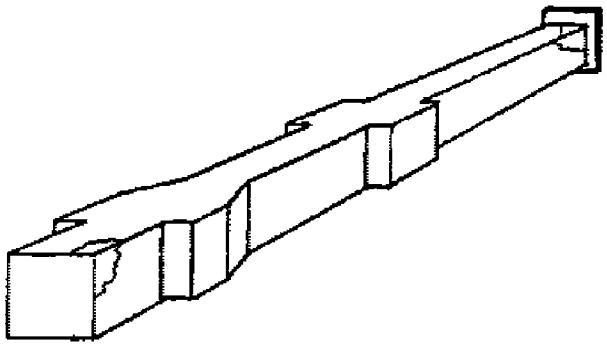
Description — This crack begins at the end of the column and extends longitudinally from several inches up to a few feet. It is usually located in the plane of a strand.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Improper release. 1. Improper procedure for detensioning. 2. Slippage and impact from dirty strand. B. Improper stripping and handling. 1. Strand not completely cut prior to stripping. 2. Strand caught in header. 3. Improve header removal. C. Improper production. 1. Indentations or joint offsets in forms. 2. Binding in forms. 3. Improper end curing.	A. Proper release. 1. Anneal strand prior to cutting. 2. Keep strand clean. B. Better stripping and handling techniques. 1. Insure that all strands are fully cut. 2. Allow member to drift away from headers when lifting. 3. Separate header from concrete before lifting. C. Improve production methods. 1. Keep forms in good repair. 2. Keep forms clean and properly oiled. 3. Prevent heat loss at headers.	The severity of this condition depends upon the design criteria for connection fixity at the base and top of the column.	Inject with epoxy to repair.
			

5. Diagonal Crack at Ends

Description — Diagonal crack extending from one face to the other.

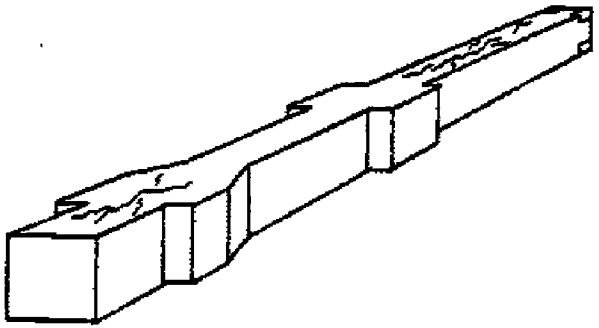
CAUSE	PREVENTION	EFFECT	REPAIR
A. Diagonal tension caused by sliding of members as prestressing strands are released. B. Form expansion with curing temperature rise if preset time is inadequate. C. Improper production. 1. Indentations in forms or joint offsets. 2. Binding of forms. D. End plate restrained in form. E. Transverse movement of member while setting it down or dragging it sideways.	A. Detension strands at both ends simultaneously by annealing. B. Lengthen preset time — Determine in accordance with ASTM C403. Do not allow temperature to increase too rapidly. C. Improve production methods. 1. Keep forms in good repair. 2. Keep forms clean and properly oiled. D. Eliminate or reduce restraint of end plate. E. Handle members carefully so that lateral forces are not applied.	The severity of this condition depends upon the design criteria for connection fixity at the base and top of the column.	Inject with epoxy to repair.



6. Miscellaneous Cracks

Description — Fine, shallow cracks; also coarse cracks with adjacent surfaces sloping into cracks.

CAUSE	PREVENTION	EFFECT	REPAIR
A. Surface shrinkage. 1. Excess water in concrete. 2. Rapid moisture loss. 3. Heat applied too early in the curing cycle. 4. Excessive curing temperatures. B. Settlement of concrete around top reinforcement (subsidence). C. Insufficient vibration.	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. 3. Lengthen preset time — Determine in accordance with ASTM C403. 4. Reduce curing temperatures. B. Allow time for initial settlement and revibrate the concrete. C. Use sufficient vibration to eliminate voids under top reinforcement.	Unless column is exposed to a corrosive environment, repair is not necessary.	If required, inject with epoxy or patch with grout.



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