cylinders, two cylinders from each cluster shall be tested to determine compressive strength, and three cylinders from each cluster shall be used when using 4 x 8 cylinders. The reported compressive strength shall be the average of the strength measured of the two or three cylinders tested as specified above in accordance with ASTM C39. The test results shall be recorded in a bound log book along with the date of casting and the age of the cylinder at testing and made available to the Department inspector. Detensioning or handling an element prior to obtaining the release compressive strength will be cause for rejection.

Concrete batches from which cylinders are made shall be tested for slump in accordance with ASTM C143, and for air content in accordance with ASTM C231.

The Contractor shall maintain records of tensioning operations, curing temperatures, and concrete testing in a form suitable for permanent filing. Records shall be available to the Department and maintained for 10 years.

405.05—Procedures

(a) **Forms:** Forms and centering shall be made and maintained true to the shapes and dimensions shown on the approved drawings.

Forms shall be of metal or other material that will give comparable results. Forms shall be designed and aligned so that they will not restrict the longitudinal movement of the casting when the pre-stressing force is transferred.

Drilled holes in bulkheads and templates shall be sized to provide for unrestricted movement of strands during tensioning.

Bulkheads may be constructed of adequately reinforced plywood. Wooden bulkheads that are warped or damaged shall not be used.

Form ties shall not be used without the approval of the Engineer.

Joints between panel forms shall be well aligned and tight; and adequate precautions shall be taken to prevent leakage of mortar. Corners or intersections of surfaces exposed in the completed structure shall be chamfered or rounded, with a width or radius of 3/4 inch. Corners of square piles shall be chamfered from 3/4 inch to 1 1/2 inches or rounded to a 2-inch radius. A smaller chamfer not less than 3/4 inch may be used if approved by the Engineer.

Void forms shall be anchored during concrete placement and secured by means other than being tied to strands.

The material used to form internal voids for voided slab and box sections shall be expanded polystyrene having a maximum water absorption (by volume) rate of 10%.

The use of waxed-coated cardboard tubes shall not be permitted.

Precast prestressed concrete box beams and flat slabs shall have one drain provided in each end of each void. The drain shall be located so that the void will drain after the unit has been installed in the structure. The device for forming the drain shall be of such material and design that the drain will not rust, stain, or otherwise disfigure the concrete and shall allow free drainage from the void.

(b) **Placing Strands and Wires and Applying and Transferring Pretension:** The Contractor may be required to submit for the Engineer's approval the detailed computations of gage pressures and elongations proposed.

All steel reinforcement shall conform to Section 406. Wires shall conform to the requirements herein for strands.

The Contractor shall not substitute stress-relieved strands for low-relaxation strands.

Strands with kinks, bends, nicks, broken wires, scales, rust, or other defects shall not be used. The failure of one wire in a seven-wire pretensioned strand or one wire in a parallel-wire post-tensioned cable may be accepted provided the wire is not more than 2 percent of the total number of wires. Slight rusting will not be cause for rejection provided it is not sufficient to cause visible pits. Strands shall be satisfactorily cleaned before concrete operations begin.

Strands shall be placed in proper position and first tensioned individually by a force of at least 5 but not more than 25 percent of the final stressing force. This force shall not vary by more than 5 percent in any group of strands.

The final stressing of strands shall be performed by applying tension to each strand individually or to all strands as a group. The strand or strand group shall be tensioned to the total pretensioning force as indicated on the plans, with a maximum applied stress of 70 percent of the ultimate strength for stress-relieved strands and 75 percent of the ultimate strength for low-relaxation strands.

During stressing, allowance shall be made for the amount of strand anchorage slipping. The proper allowance shall be determined during trial plant operations and satisfactorily checked periodically during actual stressing operations. Strand anchorage devices of each type and source shall be checked as specified herein.

During stressing, allowance shall be made in the amount of strand elongation for the loss or gain in tension resulting from the change in temperature in the strand between the time of stressing and time of the initial set of concrete. The magnitude and method of application of this allowance shall be in accordance with the *PCI Manual for Quality Control* (MNL-116).

A manufacturer's corresponding recommended value for the average modulus of elasticity will be used for each order of strand supplied. Consideration shall be given to the stress-strain data of tests performed on the samples.

Strands shall not be spliced within units.

Pretensioned strands shall be secured by suitable anchorage devices capable of developing at least 90 percent of the ultimate strength of the strand.

When deflected strands are tensioned in their deflected position, they shall be supported by lubricated rollers with solid bushings or other low-friction rollers at hold-up and hold-down points. Provisions shall be made for a cover of at least 1/8 inch of concrete or epoxy mortar on metal parts of the hold-down devices remaining in beams.

The final position of strands and reinforcing steel shall be accurately maintained as shown on the plans.

The tensioning system shall be equipped with a pressure gage indicating the jack pressure to an accuracy of within 2 percent of the pressure corresponding to the full prestress tension in the strand. Gages shall be recalibrated at least once every 6 months, at any time the gaging system appears to be giving erratic or erroneous results, or if the gage indication and elongation measurements indicate materially different stresses. Gages, jacks, and pumps shall be calibrated as a system in the same manner in which they are used in tensioning operations. Calibration shall be performed by an approved testing laboratory or approved calibration service, and a certified calibration curve shall accompany each tensioning system. Load, as measured by gage pressure, shall not vary from that measured by elongation by more than 5 percent. Elongation measurements shall be taken as checks on the final pressure gage reading. Elongation shall be measured to a precision of 1/4 inch. The Contractor shall record elongation and pressure readings during stressing. Calibration documentation shall be provide to the Department representative upon request.

Tension in the strands shall not be transferred to the concrete in the unit until the concrete has attained a compressive strength of f' ci, in accordance with Section 405.04. Strands shall be transferred gradually, simultaneously, and equally to the concrete when multiple-strand detensioning is used.

When the single-strand release method is used, strands shall be released by heating near the end of each unit in accordance with the Contractor's sequence and schedule. Individual jack release or burning may be used for strands at the dead or live end of the bed. Strands to be released in each step of the sequence shall be burned apart between beams before the next step is begun. No more than two strands shall be included in each step of the pattern.

Strands shall not be burned quickly but shall be heated with a low-oxygen flame played along the strand at least 5 inches until the metal gradually loses its strength and failure of the first wire in each strand occurs after the torch has been applied for at least 5 seconds.

The schedule for single-strand detensioning of units having deflected strands shall incorporate the following:

1. Straight strands located in the upper flange of the unit shall be released first.

2. Tension in the deflected strands at the ends of bed and uplift points shall be released in sequence.

3. Hold-down devices for deflected strands shall be disengaged, and hold-down bolts shall be removed from units.

4. The remaining straight strands of the pattern to be detensioned individually shall be released in sequence.

If it is desired to release hold-down devices prior to releasing tension in deflected strands, this may be permitted if the weight of the prestressed unit is more than twice the total of the forces required to hold strands in the low position, or if weights or other approved vertical restraints are applied directly over the hold-down points to counteract uplifting forces at least until the release of deflected strands has proceeded to such a point that the residual uplifting forces are less than 1/2 the weight of the unit.

Failure to follow these procedures may result in rejection of the units.

(c) **Placing Concrete:** The procedure and equipment for handling, placing, and consolidating concrete shall be such that a uniformly dense and high-grade of concrete is obtained in all parts of the unit under all working and weather conditions.