Chapter 6:
SHOP DRAWINGS AND OTHER SUBMITTALS
A GUIDE FOR SHOP DRAWING ENGINEERS, AGENCIES, PRECASTERS AND CONTRACTORS

Shop drawings are detailed working drawings, usually prepared by precast fabricators, to show the information needed for precast panel fabrication and installation because contract drawings and specifications typically do not include that level of detail. A complete set of shop drawings includes a production note sheet, one or more sheets of "standard" panel details, detailed drawings of each panel and/or a compilation of panel dimensions, and a panel layout drawing, when appropriate. Detailed descriptions of these sheets are provided later in this chapter.

Shop drawing engineers (SDEs), usually employed by the fabricator, use contract plans and specifications as their primary sources of information for preparing shop drawings. Other important information, such as specific panel size and connection details, need to be gathered from system designers, contractors and precast fabricators. The SDE assimilates all this information and reduces it to detailed panel fabrication drawings that are acceptable to all parties.

It is frequently necessary to resolve differences between the contractor’s desires and the owner’s specifications. While some differences may be easily resolved with a phone call, it is typically more efficient to resolve them in a pre-construction meeting – where all parties are present – before proceeding with full-scale shop drawing development. More information about pre-construction meetings is presented in Chapter 10.

This chapter focuses on developing shop drawings that are sufficiently clear and complete so that they may be reviewed in a timely manner and be subsequently followed by precast and installation personnel without intense guidance from SDEs. Shop drawings play a significant role in the quality fabrication and installation of precast panels.

Starting The Shop Drawing Process – Gathering Necessary Information

Information Gathered From Contract Plans and Specifications

Limits and Locations of Repair

Repair locations and limits, usually defined by project stations or mile post markings, are typically shown in the contract plans, as shown in Figure 6.1, and in accompanying “tables of quantities,” as appropriate for each project. Repair locations on some simple intermittent repair projects are shown only in a table (with no plan sheets), as seen in Figure 6.2.

Figure 6.1. Example contract drawing showing intermittent repair locations relative to mile posts.
The SDE should be aware that repair locations shown on most contract plans are approximate because additional pavement deterioration often takes place between the time the project is designed and when the work is completed. For this reason, most contract plans include a note stating that actual repair limits will be determined by the project engineer-in-charge (EIC) just prior to the development of shop drawings.

**Thickness of New Panels**

The SDE will usually find the thickness of the new panels in the cross-sections and, sometimes, in the panel detail sections included in the contract documents. If the specifications allow the contractor to submit different thicknesses for approval, the SDE will likely be required to submit supporting calculations. Owner review and approval of these calculations may require additional time, a factor that should be considered in the project schedule. The fastest way to get shop drawings approved is to use the thicknesses shown in the contract documents.

**Nominal Lengths and Widths of New Panels**

Nominal panel sizes are often shown in contract plan drawings, as shown in Figure 6.1, or in tables, as seen in Figure 6.2. Most contract specifications leave final determination of panel lengths and widths up to the contractor and precaster (subject to review and approval by the owner’s engineer) because field dimensions between existing joints, shipping regulations and erection equipment influence the determination of appropriate project panel sizes.

Maximum and minimum panel length information is usually shown on standard panel detail sheets. Exact panel width, however, is shown on the contract plans only if new longitudinal joints are to be established. If existing longitudinal joints are to be preserved on an existing multi-lane interstate roadway, the SDE must determine the correct width for each panel from information obtained from the contractor’s surveyor, as is discussed later in this chapter.
Dowel Bar Size and Spacing

Dowel bar sizes and spacings are typically found or referenced on the standard panel detail sheets. Most contract drawings show only “standard spacing” of dowels (e.g., 12-inch centers when dowels are used across the entire transverse joint or when three or four dowels are spaced uniformly in each wheel path); they typically do not address variable spacing between sets of dowels when they are used in panels with varying widths. Those dimensions usually need to be determined by the SDE on a case-by-case basis.

Tie Bar Size and Spacing

Tie bar information is usually found on the standard panel detail sheets, but is typically provided for only “standard length” panels. Because new precast panels vary in length, it is the SDE’s responsibility to space tie bars in panels of each length such that they do not interfere with slots or cast-in dowels for transverse joints at the end of each panel. It is typically best practice to make the spacing of tie bars in any given panel equal to the distance shown on the standard panel detail sheet and vary only the space between the last tie bar and the end of the panel at both ends of the same panel.

If new panels are to be placed adjacent to existing pavement in an adjacent lane, as is the case with two panels in Figure 6.3, the procedure for establishing tie bar spacing should be the same regardless of possible incidence of transverse joints in the adjacent pavement. If a transverse joint in an adjacent lane abuts the new precast panel at a location away from the precast panel joints, use only the slots in the new panel on one side of the abutting joint (usually the side that offers the most slots). This concept is discussed in more detail in Chapter 9.

Reinforcing Layout

The size and spacing of reinforcing bars are sometimes shown on the standard panel detail sheets in the contract drawings. However, it is more common to find reinforcing requirements in the project specifications, usually in the form of a minimum required steel/concrete ratio. The SDE must convert that requirement to reinforcing bar size and spacing and add additional steel as necessary (e.g., around...
lifting inserts, around openings for utilities and as necessary for special handling and loading conditions). At least one manufacturer adds a second layer of reinforcing steel to accommodate construction or highway traffic loading before the panels are fully grouted.

**Surface Finish (Texture)**

The type of required surface finish or texture is typically found in the project specifications or on the sheet of standard panel details. The SDE and the owner’s reviewing engineer should be aware that profile grinding of the finished surface to meet ride quality requirements, if required, will remove much, if not all, of any finish texture applied during panel fabrication. If a deeply textured finish and profile grinding are required on the same precast pavement surface, the SDE should point out the incompatibility of these two requirements to the agency’s engineer and ask for official clarification. This topic is discussed further in Chapter 10.

While placing equipment is crucial in determining panel size, maximum allowable shipping width is sometimes a governing factor. The contractor and the precaster responsible for shipping the panels must mutually determine the final dimensions of the panels to minimize freight costs and maximize the area of panels that can be placed in any given shift.

**Order of Panel Placement**

The SDE must determine the order in which the panels are to be placed (using information obtained from the contractor) so dowels and accommodating slots are cast in the panels correctly. Contractors usually set panels in the same direction as the traffic flows to aid in access and egress of delivery trucks, but some situations may demand placement in the opposite direction, requiring different dowel and slot locations. In some cases, it may be necessary to lay panels from each end of a repair area and meet in the middle.

The SDE must be sure to detail the panels to allow panel placement as required by the contractor.

**Schedule of Panel Placement**

The contractor should develop a schedule of panel placement so the SDE can prepare shop drawings in a timely manner. The contractor should also allow time for collection of field measurements, shop drawing preparation, submittal and approval when developing the placement schedule.
Field Survey to Determine Panel Widths (Intermittent Repairs)

Most specifications require that contractors gather necessary field survey information to develop accurate, project-specific shop drawings. For intermittent repair (patching) projects, the field survey may be as simple as measuring the distances between longitudinal joints at each repair location. It is typically necessary to take such measurements at each repair location because existing longitudinal joints are seldom perfectly parallel and the distance between them can vary significantly from panel to panel.

It is imperative that measurements between longitudinal joints be made perpendicular to the longitudinal joints, because even a “modest” deviation from perpendicular may result in an incorrect measurement and a panel that will not fit. It is also imperative to locate the true edges of the panels below the pavement surface when making these measurements because using the edges of the joint reservoir cuts at the pavement surface may lead to incorrect measurements. It is advisable to either remove the joint sealant before measuring or to use a probing device – such as an ice pick – to penetrate the sealant and find the true edges of the longitudinal joints (Figure 6.5).

Area Field Surveys to Gather Topographical (3-D) Information

To develop shop drawings for area placements (e.g., continuous single or multiple lanes, ramps, intersections and toll plazas), it is frequently necessary to obtain field survey information taken by the contractor’s surveyor. Such surveys are sometimes required by contract specifications, but even if they are not, it is advisable to perform detailed field surveys to ensure the new panels are designed to fit the prescribed area and create the surface required by the contract plans.

Topographical (3-D) surveys of precast pavement installation areas are performed for two reasons: 1) to determine the exact “x”, “y”, “z” coordinates of boundary features (e.g., curbs, catch basins, utility features, and existing longitudinal and transverse joints, including shoulders and ends of bridges), and 2) to capture “x”, “y”, “z” information related to the existing pavement surface, utilities and other appurtenances that may reside in the area to be replaced.

Topographical surveys of pavement areas are typically taken by qualified surveyors using conventional or robotically controlled total stations (requiring only one surveyor), such as the one shown in Figure 6.6. Area surveys of this type can also be performed using lidar (light detection and ranging) scanning equipment as long as it is sufficiently accurate to meet the precast pavement panel dimensional tolerance indicated in the specifications (typically +/- 1/8 inch).

Shots taken with total station equipment should be taken at exact boundary points (as necessary to meet existing joints) and at exact corners, edges and tops of drainage castings.
and other utilities. To capture the elevations of an existing pavement surface, total station shots should be taken on 10- to 15-foot centers, depending on the severity of contour change of the existing pavement. Lidar scanning equipment, on the other hand, captures all this information in the same scan, but the required information must then be extracted by surveyors trained specifically for that equipment.

It is ultimately the SDE’s responsibility to reduce the topographical survey information to a digital surface model, as described later in this chapter.

**Information Gathered From System Designers**

System designers are individuals or entities who have developed a set of proven, panel-specific details, materials and associated installation methods that satisfy the four basic requirements of JPrCP listed in Table 1.1. For preparing shop drawings, the SDE should draw information from the standard system detail sheets the system designer previously developed for the system approval process (this is discussed in more detail in Chapter 10). Details that should be extracted from standard system detail sheets include – but may not be limited to – details for encased dowels and tie bars, matching slots or oversized holes, lifting inserts, leveling inserts for grade control, and grout retention devices for bedding and dowel grouts (if used).

**Information Gathered From Precasters**

The SDEs should consult with the precaster personnel who are responsible for fabricating and shipping the new panels to learn about any specific limitations or other factors that will impact the development of panel details for the project. For example, the precast manufacturer’s forming equipment may limit maximum panel sizes and may also limit how dowels may be positioned in variable-width panels. Precasters should also be consulted to provide legal shipping width information, which varies between states and may also vary among different municipalities in the same state. Most states require escort cars for loads greater than 12 feet wide, so precasters try to avoid that cost by keeping panel width at less than 12 feet as placed on the truck. Similarly, precasters try to minimize freight costs by sizing the panels so each truck load, often consisting of two or more panels, weighs as close to the maximum legal load as possible (without exceeding the legal load).

To illustrate this concept, consider that a panel 12 inches thick by 13.33 feet long by 12 feet wide weighs 24,000 pounds, just half of 48,000 pounds, a payload weight that is legal in most states (without requiring an overload permit). That length of 13.33 feet, therefore, is the most freight-efficient length for panels of that thickness and width since two panels can be shipped on a single truck. Longer panels (up to about 16 feet) may be more efficient to place in the field (i.e., resulting in higher lengths of pavement replacement per shift for any given number of panels placed per shift), but obviously will be much costlier to ship since only one such panel can be shipped on a standard truck.

**Pre-Construction Meeting**

Once the SDE has gathered the information discussed above, it is advisable (and often required) to convene a pre-construction meeting with all project stakeholders (i.e., the project owner, engineer, contractor, subcontractors, etc.) to ensure everyone agrees upon the proposed panel details and the panel layout scheme as they relate to conformance to the specifications, installation productivity and the quality of the finished installation. Developing a consensus at this point will facilitate shop drawing preparation, enhance accuracy and hasten subsequent review and approval of the completed drawings. A pre-construction meeting will also aid the contractor in planning to fabricate and install the panels as well as help the owner in preparing to supervise and inspect the project, as is discussed in more detail in Chapter 10.

**Shop Drawing Content**

The following section addresses what should be included in the shop drawing submittal package to ensure all aspects of the fabrication process are addressed. Shop drawing content varies with project type. For example, more panel geometry information needs to be included for a project where non-planar panels are used than for one using only single-plane (flat) panels.
Production Note Sheet

The production note sheet, typically the first sheet of the shop drawing package, is meant to provide general production requirements and guidance (to precaster personnel) to ensure compliance with the project specifications. It also typically includes general information concerning the materials to be used in panel fabrication and describes the manufacturing processes, including curing, storage and shipping. The following information should be included in the production note sheet:

1. General notes related to conformance to specifications
2. Concrete data (stripping and 28-day compressive strengths, mix design, testing, etc.)
3. Sources of cement, aggregates, reinforcing and other hardware used in manufacturing the panels
4. Concrete mix design
5. Concrete delivery method
6. Casting information (method of pouring, screeding, finishing, etc.)
7. QA/QC procedures
8. Curing procedures
9. Fabrication tolerances
10. Yard storage information
11. Shipping information
12. System-specific information, as necessary

Panel Detail Sheets

Panel detail sheets show all the details of the panels to be manufactured for the project. Only a single sheet may be needed if the details of all the panels are the same and only the size changes. However, many sheets may be required if there are a number of different types and configurations of panels on the project.

The following information should be shown on the detail sheets:

1. Dowel and tie bar encasement details
2. Dowel or tie bar receiving slot and/or oversize hole details
3. Lifting or lift/leveling insert details
4. Dowel bar and bedding grout port details
5. Panel reinforcing details
6. Grout retention system details, if used
7. Dowel bar spacing and edge distance details
8. Other system-specific details

To aid the SDE in setting up an efficient shop drawing format, consider, for example, a panel shop drawing taken from a set of drawings that were developed for a specific project (Figure 6.7). The drawing shown in Figure 6.7 depicts a “Slab Type A.” The use of lettered side and end dimensions on this drawing allowed the SDE to use it for many different sizes of Type A panels as long as the edge details remained the same, as indicated in the drawing.
Details for the two transverse edges of the standard Type A panel (shown in Figure 6.7) are stand-alone drawings as shown in Figure 6.8. Details of the other two (longitudinal) edges were included elsewhere on the same sheet of the shop drawings for that project but are not included here for simplicity. Note that the edge details shown in Figure 6.8 applied to all Type A panels, even though edge dimensions, also not shown here for simplicity, changed as necessary. The technique of showing stand-alone edge details allowed the SDE to refer to them for other types of panels (Type B panels, for example) as well, saving drawing time and shop drawing sheets. This demonstrates the efficiency of establishing a sheet of edge details that may be referenced from several plan view drawings for several panel types.

This method of detailing was adequate for fabrication and efficient for drawing purposes, but additional distinguishing “mark numbers” (not shown in Figure 6.7) were necessary to identify each differently sized panel for storage, shipping and placement.

Features other than differing panel edges may trigger the need for additional plan view shop drawings. For example, unique shop drawings are needed for each panel when it is necessary to provide blockouts for manholes, catch basins, water valves or other utility structures. Precast pavement projects of even modest complexity may require a number of shop drawings for fabrication and installation purposes.

**Establishing Dimensions for Intermittent Repair Panels**

Because intermittent repair panels are often randomly located throughout a project, they are usually sized to fit each location. In most cases, longitudinal joints are retained, so the SDE will need to determine the width of each panel from information provided by project surveyors, as discussed earlier in this chapter.

The lengths of intermittent repair panels are usually established by the contractor within maximum and minimum limits indicated in the project specifications. Contractors typically establish a “menu” of standard panel lengths (e.g., 6 feet, 8 feet and 10 feet) to best address the variety of required project repair lengths. Consideration is also given to minimizing fabrication and freight costs and maximizing placement efficiency (using equipment the contractors owns) when establishing the project panel menu.

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**Figure 6.8.** Example JPrCP transverse joint cross-sections showing an embedded dowel on one side and a matching bottom slot on the other.
Establishing Dimensions for Lane Replacement Panels

On lane-replacement projects, panels are typically placed continuously over longer distances. It is typically considered a “best practice” to cut at least one new longitudinal joint approximately 2 inches into the adjacent lane so the new panels are all the same width (typically slightly wider than 12 feet) within any given replacement segment. This practice also eliminates deteriorated concrete that may exist along the existing longitudinal joint.

The precaster and the contractor typically work together to establish the lengths of new panels on lane-replacement projects. Their goal is to minimize freight cost and to establish panel weights that the contractor can favorably manage at the site.

If the widths and lengths are constant, the SDE may need to develop only a minimum number of shop drawings for the project. If, on the other hand, the lengths are constant and the widths vary (as in the case where the existing longitudinal joints are retained), the SDE will likely find it necessary to develop more shop drawings (and/or tables) with properly developed mark numbers assigned to each panel.

Using Rectangular Panels in Horizontal Curves

A single rectangular panel design can be used on roadways of any curvature (see Figure 6.9) if the distance between the adjacent curved roadway lane and the center of the edge of the new panel (i.e., the middle ordinate) does not exceed the maximum allowable longitudinal joint width. When rectangular panels are used in such locations, it is imperative the transverse saw cuts in the existing pavement match the rectangular shape depicted in the shop drawing. More detail on this is offered in Chapter 8. The SDE will likely be responsible for checking middle ordinates based on curve data provided by the contractor’s surveyor. However, the contractor’s surveyor will be responsible for laying out the transverse saw cuts properly, as discussed in Chapter 8.

A series of rectangular precast panels can also be used on slightly curved roadways (see Figure 6.10) as long as the middle ordinate of each panel does not exceed the maximum allowable longitudinal joint width, the transverse joint width at the outside of the curve (“W” in Figure 6.10) does not exceed the maximum allowable transverse joint width, and the cuts in the existing pavement at the ends of the series of panels are made to match the rectangular panels (see Chapter 8 for more details). The SDE will be responsible for ensuring the first two criteria are met while the contractor’s surveyor will be responsible for the third. Notice that the end transverse cuts are not likely to be radial to the curve if rectangular panels are used in a horizontal curve.

The SDE may determine middle ordinate and “W” dimensions using basic circular curve geometry. To do this, the lengths and widths of the rectangular panels must be known and the radius of the curve must be provided by the contractor’s surveyor, as discussed earlier in this chapter.
Transverse joint widths and middle ordinate values ("W" and "MO," respectively) for a selection of typical 12-foot-wide rectangular panels placed in roadways of various radii are shown in Table 6.1. The table shows that "W" exceeds allowable transverse joint widths (typically 1/2 inch or .04 feet) at relatively large radius curves—roadways that appear to be "relatively straight." To avoid exceeding specified joint widths, it is generally best practice to use trapezoidal panels that are designed to fit each curve exactly.

### Designing Trapezoidal Panels for Horizontal Curves

Trapezoidal panels may be designed and dimensioned to fit any horizontal curve if the radius of the curve, the width of the lane and the length of the panels are known (Figure 6.11). While this information may be shown on the contract drawings, it should be checked and provided by the contractor’s surveyor to ensure panels are designed accurately. To ensure a proper fit, the SDE should design transverse edges of all trapezoidal panels along radials of the curve. Longitudinal edges may be designed as straight chords if the resulting middle ordinates do not exceed the maximum allowable longitudinal joint width. When straight chords do exceed that limit, which is typically 3/4 inch or .06 feet, it will be necessary to design panels with curved longitudinal edges.

The middle ordinate of a 14-foot-long panel with straight longitudinal edges (chords) placed in a 400-foot radius curve is approximately 3/4 inch or .06 feet, the typical maximum allowed longitudinal joint width. Therefore, it is usually necessary to design 14-foot-long panels with curved longitudinal edges for radii less than 400 feet to avoid exceeding the joint width limit. Alternatively, shorter panels with straight chords may be used on smaller radius curves. The SDE must check middle ordinates for each proposed panel length carefully when designing panels for curves with radii less than approximately 400 feet.

### Dowel Placement in Non-radial Transverse Joints

Dowels in precast panels used in horizontal curves are typically detailed to be placed perpendicular to radial transverse joints, as they are in jointed cast-in-place concrete pavement. The sketches shown in Figures 6.9 and 6.10 indicate, in an exaggerated fashion, that transverse joints of rectangular panels in horizontal curves are not radial. In practice, they do not deviate greatly from a radial line (in most highway curves) as long as the panels are not longer than about 10 to 12 feet. Because of this, dowels are typically detailed to be placed perpendicular to the non-radial
transverse joints. This has not proven problematic on such projects completed to date.

**Designing Non-planar (Warped) Panels**

Panel dimension discussions thus far have focused on flat (single-plane) panels. The SDE should be aware that non-planar panels are often needed to accommodate or meet existing non-planar or contoured roadway surfaces. Non-planar surfaces are commonly found at the beginnings and endings of horizontal curves (superelevation transitions), at highway intersections, where new precast panels in one lane abut uneven existing pavement in an adjacent lane or at any location where the cross-slope of the roadway varies from one end of the panel to the next (Smith, 2013).

A non-planar (warped) panel, shown schematically in Figure 6.12, may be defined as one whose surface does not reside in a single plane. For illustration purposes, all points on the surface of the warped panel shown in Figure 6.12 reside above the single plane defined by corners “A,” “B” and “C.” The vertical location of corner “D,” relative to the plane formed by corners A, B and C, can be defined as the “delta” (Δ) distance shown in Figure 6.13.

The rectangular warped panel shown in Figure 6.12 is further defined as one in which all the sides of the panel are vertically straight and cross-sections taken perpendicular to any side vary linearly from one end (or side) of the panel to the other. This configuration of a non-planar panel is proprietary to The Fort Miller Co., Inc.

While the geometry of the warped panel shown in Figure 6.12 may appear to be complex, it’s relatively easy to determine, define and include in the shop drawings. The delta distance is the only information needed to adjust corner “D” (of the bed) to the correct elevation as long as corners “A,” “B” and “C” are placed level on the casting bed. Ultimately, non-planar panels cast in this manner are placed in the field to the correct “x-y-z” field coordinates for all four corners.

Shop drawings for warped panels are best developed by first creating a digital surface model of the area to be replaced. Surface models may be developed from theoretical pavement grades and cross-slopes shown in the contract drawings. In rare cases, contract drawings may include a panel layout drawing that shows “design elevations” of each corner of each panel, essentially eliminating the need to develop a digital surface model. In some cases, a design surface model of the replacement area can be obtained from the DOT.

In general, however, the SDE should ultimately use topographical survey information gathered by the contractor’s surveyor, as discussed earlier in this chapter, to check any surface model provided by others or as the primary source of elevation data if that information is not available from any other source.

The “x,” “y” and “z” coordinate values of each corner of each panel surface can be digitally extracted from the design surface model by superimposing a panel layout drawing on the surface model using commonly available software. The
delta values described above can be determined once the “x,” “y” and “z” coordinate values of each corner are known. Delta values for all panels should appear on the shop drawing general information table and on any shop ticket that is used for fabrication.

Note that warped panels described above are rectangular (plan view) in tangent (straight) portions of the roadway and trapezoidal the curved portions.

**Establishing Dimensions for Panels of Any Shape**

Panels with shapes not described above may be required in some locations, such as intersections, ramp termini and bridge approach slabs, where roadway alignments are not square or straight. Panel dimensions for such locations are best established by developing a digital surface model of the overall area as described above. Once a panel layout for the area is developed, exact panel dimensions can be determined (extracted) by combining the panel layout drawing with the digital surface model, also as described above.

The SDE will find it useful to work with “master drawings,” such as those shown in Figure 6.14, to show dimensions of each panel as well as other auxiliary dimensions that will be useful specifically for form setup. Auxiliary dimensions, such as “WD” and “HD” in Figure 6.14, are typically included in shop ticket drawings (discussed later in this chapter) to aid precasters in setting up forms without extra support from the SDE or other surveying personnel.

**Detailed Drawings for Special Panels**

It is highly likely that special panels will be required to accommodate utility structures on urban arterial and city street projects. Since such panels are not easily described in general sketches of the type shown in Figure 6.14, it is typically necessary to develop separate detailed drawings for these features, such as the one shown in Figure 6.15. These drawings may also need to include (or reference) special cross-section (edge) views that are panel-specific. Diagonal dimensions, as shown in Figure 6.15, also aid precasters in setting up their forms.

**Organizing Panel Dimensions**

It is typically necessary to calculate and track many dimensions on large projects (especially for projects involving horizontal curves) for fabrication, shipping and installation purposes. To manage this information efficiently and accurately, the SDE should develop a “master table” of panel dimensions and other critical information, as seen in
Figure 6.15. Example detailed shop drawing (and accompanying reinforcement table) for a special panel containing a manhole blockout.

Figure 6.16. The tabulated information should include at least the following:

1. Mark number (label or designator) of the panel
2. Quantity of each mark number
3. Panel type
4. Form type (if required by the precaster)
5. Panel area
6. Panel volume (cubic yards)
7. Panel weight
8. Panel delta (for warped panels)
9. Lengths of line segments shown in Figure 6.14
10. Panel diagonals (for shop use) shown in Figure 6.15
11. Reinforcing bar list
12. List of embedded hardware (dowels, tie bars, lifting inserts, etc.)
13. "x," "y" and "z" values of each corner of every panel

Notice that the "x," "y," and "z" values (No. 13 in the list above) are not included in the table shown in Figure 6.16. For the sake of clarity, it's often better for the SDE to develop a separate table of these values that is prepared specifically for the project surveyors responsible for panel layout at the site, as discussed in Chapter 8.
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<th>VOLUME (CYD)</th>
<th>WEIGHT (TON)</th>
<th>DELTA @ D</th>
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**Match Line**

Figure 6.16. Example of a detailed "master table" of information that is useful for fabrication, shipping and installation.
Site Drawing Indicating Panel Layout

Panel layout drawings show where each panel is located (by mark number or label) on the project site. Such drawings may not be necessary for intermittent repair projects, but they are essential for continuous and large-area projects. They are used by surveyors for layout purposes and by placement personnel that need to know the intended location of each panel.

An example of a panel layout drawing is shown in Figure 6.17. Every panel is labeled with a mark number on the drawing that corresponds to a mark number painted or stenciled on the appropriate panel. Stations and additional dimensions may also be shown to further clarify the panel layout. Section arrows shown in Figure 6.17 refer to detailed cross-section drawings shown on other sheets of the shop drawings for this project.
Shop Tickets

Shop tickets (sometimes called shop cards or cut sheets) are drawn exclusively for precaster personnel responsible for fabricating the panels and are not typically included in the shop drawing submittal package. They typically include only information that is essential for setting up the forms, rebar, slot formers and embedments (i.e., dowels, tie bars and lifting inserts) for each panel. They also include information used by supervisors and QC personnel responsible for inspecting the panels, as discussed in Chapter 7. It is important to show all shop ticket information in a simple, easy-to-read format so fabrication and inspection errors can be avoided.

An example shop ticket is shown in Figure 6.18. Notice that, in addition to basic panel dimensions and rebar information taken from the previously referenced "master table," the shop
ticket also indicates the form type, slab type, delta value, panel volume and panel weight. This information is useful to precasters and personnel responsible for storing and loading the panels for shipment.

**Summary**

A complete set of shop drawings is a vital part of the precast panel production and installation processes because it contains detailed information that is needed for the fabrication and placement of every project panel. Shop drawings are developed by shop drawings engineers (SDEs) using information shown in the contract plans and specifications and additional information obtained from contractors, system designers and precasters.

Before developing any shop drawings, the SDE must first ensure the information gathered from the various sources is in agreement and contains no conflicting information. Any conflicts must be resolved with the information providers. Some differences can be resolved with a phone call, but it is a good practice to hold a formal pre-construction meeting where plans, specifications, and panel and installation details can be reviewed thoroughly so the SDE has a clear mandate from all project participants before any effort is expended on shop drawing preparation.

While it is always desirable to minimize the number of different types of panels (and, therefore, the number of shop drawings), it is typically necessary to develop multiple drawings to adequately cover the many different panel dimensions and edge details that are needed to complete even a moderately sized project. This may also be true on lane replacement projects and even on some extended intermittent repair projects involving horizontal curves, superelevation transitions and intersecting roadways.

This chapter provides guidance for shop drawing engineers regarding what should be included in the shop drawing package, efficient shop drawing formats and how dimensions for the many different types of panels are determined and shown. Emphasis is placed on the importance of developing shop drawings that are complete, accurate and easy to read to facilitate the review, fabrication and installation processes, and to ensure the fabrication of precast panels of the highest quality.