

BRIDGE CONSTRUCTION MANUAL

GUIDELINES TO PROJECT SUPERVISORS

First Published: January 1981
Second Edition: April 1993

PREFACE

This Manual has been prepared to assist the Project Supervisor in the supervision of bridge construction projects. Its intent is to establish a basis for the relationship with the Contractor and to provide a guide for the uniform interpretation and application of the Construction Agreement, Special Provisions (Schedule 3) and "Standard Specifications for Highway Construction". Emphasis is placed on "Quality Control" and "Quality Assurance" of the project and the safety aspects of the construction operations.

The quality assurance plan identifies the tasks the Ministry must perform during construction to meet its quality objectives. It encompasses the pre-tender and pre-construction quality tasks (prevention) and quality tasks during operations (conformance). Pre-construction quality assurance planning includes review of contract documents, site inspection and confirmative survey to detect potential problems and seek corrective action before construction. Quality tasks during operations include quantity surveys, pile driving, pre-pour inspection, deck placement, product evaluation, material review, quality reporting, record keeping, quality audit and corrective action. The attitude of doing things right the first time and the total commitment to quality involves everyone.

Proper record keeping during the course of the contract will assist in minimizing various claims from the Contractor. Clarification on contractual issues shall be referred to the Project Manager. The Project Manager shall be made aware of technical and construction problems before referring to the Regional Bridge Engineer/Geotechnical Engineer/Design Engineer and subsequently, if unresolved, to the Senior Bridge Construction Engineer.

Accounting instructions are available in the Ministry's "Contract Administration Manual", and the "Highway Engineering Design Manual" and the "Construction Manual (Volume 1)" will be useful for the layout of the structure.

The Manual will be expanded and revised on a regular basis and your comments and suggestions should be directed to the Bridge Engineering Section, Engineering Branch.

INDEX

1. Control of Work
 - 1.01 General
 - 1.02 Responsibilities and Objectives of Project Supervisor
 - 1.03 Authority of Project Supervisor
 - 1.04 Project Diary
 - 1.05 Progress Photographs
 - 1.06 Relations with Contractors
 - 1.07 Right-of-Way
 - 1.08 Road Closures
 - 1.09 Relations with Other Agencies
 - 1.10 Occupational Safety and Health Program
 - 1.11 Industrial Health and Safety Regulations
 - 1.12 Pre-Construction Meeting
 - 1.13 Quality Assurance
 - 1.13 Alternative Details
 - 1.14 Review of Shop Drawings

2. Record Keeping and Documentation
 - 2.01 General
 - 2.02 Daily Records
 - 2.03 Weekly Bridge Construction Reports
 - 2.04 Monthly Progress Estimates and Reports

3. Surveying and Layout of Structures
 - 3.01 General
 - 3.02 Initial Site Inspection
 - 3.03 Dimensional Tolerances
 - 3.04 Triangulation
 - 3.05 Trilateration
 - 3.06 Equipment
 - 3.07 Procedure
 - 3.08 Horizontal and Vertical Alignment
 - 3.09 Setting Out Spirals

4. Piles

- 4.01 Reporting
- 4.02 Driving Details
- 4.03 Splices
- 4.04 Cofferdams
- 4.05 Hammers
- 4.06 Hammer Accessories
- 4.07 Follower
- 4.08 Mandrel
- 4.09 Churn Drilling
- 4.10 Bailer
- 4.11 Template
- 4.12 Pile Driving Analyzer (PDA)

5. Materials and Bridge Components

- 5.01 General
 - 5.01.1 Pile Installation
 - 5.01.2 Formwork
 - 5.01.3 Reinforcing Bars
 - 5.01.4 Concrete
 - 5.01.5 Bearings
 - 5.01.6 Girders
 - 5.01.7 Post-Tensioning
 - 5.01.8 Granular Backfill

6. Concrete Decks

- 6.01 Basic Considerations
- 6.02 Design Considerations
- 6.03 Screed Rails
- 6.04 Worked Example
- 6.05 Concrete Mix
- 6.06 Handling and Placing Concrete
- 6.07 Screeding Concrete
- 6.08 Finishing Concrete
- 6.09 Equipment

7. Completion Records

- 7.01 Opening and Speed Limits on New Structures
- 7.02 Substantial Completion
- 7.03 Final Inspection at Completion of Contract
- 7.04 Completion Records
 - 7.04.1 Shop Drawings
 - 7.04.2 As Built Drawings
 - 7.04.3 Concrete Deck Data and As Built Profile
 - 7.04.4 Typical Pile Driving Records Drawing

8. Appendices

- Construction Joint
- H.38 - Monthly Progress Payments
- H.47 - Concrete Inspection
- Sample Weekly Bridge Construction Report
- H.128 - Daily Work Report of Extra Work or Contentious Items
- H.177 - Work Orders/Supplemental Agreement
- H.358 - Daily Work Report for Extra Work and Provisional Sums
- Flow Chart - Guidelines to Project Supervisors
- Sample Drawing - Deck Concrete Data and "As Built" Profile
- Sample Drawing - Typical Pile Driving Records
- Flow Chart - Bridge Construction Development

9. Bibliography

CONTROL OF WORK

1.01 General

The Project Supervisor is responsible for construction administration, site inspection, record keeping and documentation of the project.

When the Project Supervisor is assigned to a bridge project, a copy of the contract drawings and documents will be provided by the Project Manager, together with relevant copies of all correspondence. Project Supervisors shall fully inform themselves of the nature and scope of the work and the true intent and meaning of the specifications regarding all items of the work. They shall be fully prepared to issue instructions and make decisions promptly on any questions raised, except for cases which must be referred to the Project Manager, Regional Bridge Engineer, Geotechnical Engineer or Manager of Bridge Construction/Bridge Construction Section for decision.

On projects where the survey will tie-in to adjacent grading projects, the Project Supervisor shall contact the Grading Project Supervisor and check the location lines and bench marks. An early check shall be made to confirm that specified clearances are secured on grade separation structures and railway overhead crossings.

A sufficient number of points and bench marks shall be furnished to the Contractor in accordance with Section 191.04 "Layout of Work" of the Standard Specifications and the Project Supervisor shall check that the Contractor's layout is correct. The Contractor is responsible for the "quality control" aspects of the construction operations.

The Project Supervisor shall check the position of substructure elements prior to pile driving operations and shall check the positioning of all formwork before concrete is cast in each section.

1.02 Responsibilities and Objectives of the Project Supervisor

- a) The Project Supervisor shall review the contract documents prior to tender and have a thorough understanding of the contract documents and other pertinent data and shall be responsible for "quality assurance".
- b) The Project Supervisor shall inspect the site and undertake a confirmative survey during the pre-tender period.
- c) The Project Supervisor and the Project Manager shall convene a pre-construction meeting with the Contractor, Ministry and other agencies.
- d) The Project Supervisor shall identify potential problems with the project and advise the Ministry prior to construction.
- e) The Project Supervisor shall ensure the work is done in strict conformance with the plans, specifications except where permitted by authorized variations, and with well established construction practice and shall extend appropriate assistance to the Contractor.

- f) The Project Supervisor shall audit the Contractor's layout, review bending schedules and perform quantity surveys on formwork and concrete on a regular basis.
- g) The Project Supervisor shall plan ahead and work with the Contractor to ensure that all efforts are complementary.
- h) The Project Supervisor shall perform the final inspection while the Contractor is still on the site.
- i) The Project Supervisor shall be aware of the safety aspects and regulations of the Workers' Compensation Board and ensure that a WCB contact person is present at the pre-construction meeting.
- j) The Project Supervisor shall ensure all instream works are constructed in accordance with the Special Provisions (Schedule 3) and Section 195 of the Standard Specifications for Highway Construction.

1.03 Authority

- a) The Project Supervisor shall not accept the use of materials, equipment or workmanship which do not conform with the specifications.
- b) On minor aspects which are not covered by the Construction Agreement, the Project Supervisor shall exercise personal judgment in making decisions, thus settling as many problems as possible at the site.
- c) The Project Supervisor may suspend work in accordance with Section 21.02 of the Construction Agreement.

1.04 Project Diary

The Project Supervisor shall keep an up-to-date diary on the project and shall record details of each day's work, weather, persons employed with trades specified, and details and usage of equipment on the site. Separate entries of the above items shall be kept for work performed under the "Order for Extra Work" and verbal instructions to the Contractor shall be documented.

The project diary shall be kept in a specially prepared book entitled "Project Daily Record." Entries shall be completed on a daily basis, and the diary shall be signed at the end of the day by both the Project Supervisor and the Contractor's Superintendent.

1.05 Progress Photographs

Photographs may be used to show irregular or unique construction techniques, illustrate application of engineering principles, controversial situations, and "before and after" views of failures or damage claims. About twenty "As-Built" photographs are essential to the construction records of the Bridge Engineering Branch.

1.06 Relations with Contractor

The Project Supervisor shall use a courteous, businesslike and ethical procedure when dealing with the Contractor. A good relationship is essential to gain the co-operation of the Contractor.

Notwithstanding the above, the Project Supervisor shall ensure that the work is done in strict conformance with the accepted engineering principles and in accordance with the drawings and contract documents.

The Project Supervisor shall maintain an impersonal, agreeable and helpful attitude towards the Contractor and the employees of the Contractor. It is an important asset to secure the friendly co-operation and respect of the employees of the Contractor by dealing fairly and by recognizing and commending on good work. The Project Supervisor shall take the attitude that any suggested changes are for the benefit of the work, and the vested authority shall NEVER be abused.

A good start is important and firmness at the beginning of the job will tend to avoid the "bickering" throughout the duration of the contract.

Instructions shall be given only to the authorized representative of the Contractor. However, on minor and routine matters, and to an extent agreeable to the Contractor's organization, instructions may be given directly to the workpersons. However, the Project Supervisor shall not act as superintendent or perform duties for the Contractor, nor interfere with the management of the work by the Contractor. Any significant orders or instructions which are likely to prove controversial shall be confirmed in writing with a copy to the Project Manager.

The Project Supervisor may deal directly with the subcontractors to an extent agreeable to the Contractor's organization. The Contractor is legally responsible for the performance of the subcontractors. Any correspondence between the Ministry and the subcontractor must be submitted through the General Contractor.

Whenever possible, circumstances which may lead to unsatisfactory work shall be pointed out at the earliest opportunity to the Contractor to avoid the waste of materials and labour.

1.07 Right-of-Way

Construction operations shall be confined within the highway right-of-way and in accordance with Section 190.29 of the Standard Specifications. The Project Supervisor shall be provided with copies of the right-of-way agreements, names and telephone numbers of the owners of the affected properties by the Project Manager. The Project Manager shall advise the Project Supervisor on properties currently under negotiation by the Property Negotiator.

The Project Supervisor shall be fully informed of the conditions of the agreement, ensure compliance and contact adjacent property owners whose accesses are affected.

The Contractor is responsible for obtaining construction accesses and storage areas if these are located outside the highway right-of-way.

1.08 Road Closures

The Traffic Management Plan submitted by the Contractor to the Project Supervisor prior to the start of the construction shall be approved by the District Highways Manager. The Project Supervisor must ensure that the control of traffic is in accordance with the approved plan and any changes required by site conditions shall require the approval of the District Highways Manager or District Representative.

Road closures shall be requested in writing by the Contractor not less than 7 days in advance of the closure for approval by the District Highways Manager. Upon receipt of the written approval, the local police, fire department, ambulance, municipality, school board and public transit shall be notified at least 72 hours in advance of the closure. The public shall be notified by local radio and newspaper at least 24 hours in advance.

The Contractor is responsible for the notification to the Ministry.

1.09 Relations with Other Agencies

A positive relationship shall be established in the early stages with the local District Highways Manager, Area Manager Bridges, Provincial and Federal Fisheries officers, and contact persons of the Workers' Compensation Board, utility companies and other agencies affected by the construction operations.

The Project Supervisor shall compile and maintain a list of addresses, telephone and facsimile numbers of contact persons for future reference.

1.10 Occupational Safety and Health Program

The Project Supervisor may request for additional documentation after the Contractor has tabled the prequalified Occupational Safety and Health Program along with revisions and additions for site specific constraints at the pre-construction meeting. Any delays or interruptions in the commencement or progress of the work as related to the acceptance of site specifics for the implementation of the Occupational Safety and Health Program shall not be considered as reimbursable delays unless otherwise agreed to in writing by the Project Supervisor.

The above requirements are supplemental to the provisions of the Workers' Compensation Board Act.

1.11 Industrial Health and Safety Regulations

The Project Supervisor shall review the following site specific components which shall be prepared by a Professional Engineer and made available at the site by the Contractor:

- a) Formwork drawings.
- b) Formwork removal details.
- c) Erection procedures.
- d) Safety net installation and removal procedures.
- e) Other approved permanent fall arrest platform.
- f) Temporary walkway on girders.
- g) All life line details.
- h) Attachment of life lines to substructure units.
- i) Falsework.

- j) Scaffolding.
- i) Demolition of old bridge.

1.12 Pre-Construction Meeting

The Project Supervisor and Project Manager shall convene a pre-construction meeting which shall be held subsequent to the award of contract and prior to the on site construction activities. All agencies with vested interest in the project shall be advised to attend and a record of the minutes of the meeting shall be kept and distributed to the participants.

A. Sample Agenda - Savona Bridge No. 0704 (Region 2-Thompson Highway District)

- (i) Introduction (Welcome address to attendees, expression of congratulations to successful Contractor, filling of Attendance Sheet with names, agencies and telephone numbers and a brief summary of the Scope of the Construction Works.)
- (ii) Lines of Communication (Confirmation of Ministry Representative and Ministry's Project Supervisor, and the contractor's Superintendent, establishment of lines of communication/correspondence between Contractor's Superintendent and the Ministry Representative.)
- (iii) Contract Administration (Letter of Award, confirmation on Bonding and Insurance and notification of WCB in writing by Contractor.)
- (iv) Contractor's Schedule (Contractor to explain on proposed schedule and table the prequalified Occupational Safety and Health program followed by a review and discussion; and Contractor to introduce Sub-Contractors.)
- (v) Environmental Issues & Utilities (Fisheries and Oceans, B.C. Hydro, B. C. Telephone and Westcoast Energy - concerns to be discussed and clarified.
- (vi) COFFEE BREAK (Agencies not involved in the subsequent items may take leave after the coffee break.)
- (vii) (Contract Documents) - (Review and clarification of all sections with the Contractor.)
 - a) Special Provisions (Schedule 3).
 - b) Contract Drawings.
 - c) Addenda.
- (viii) General Discussion
- (ix) Adjournment

1.13 Quality Assurance

The practice of quality assurance has emerged over the past five years in the industrial sector.

The quality assurance function of the Ministry Representative involves with the review of the Contractor's and Supplier's quality control reports on a regular and ongoing basis to ensure that:

- Contractor and Supplier are doing quality control as outlined in their procedures,
- Nonconformances when identified are corrected and documented in accordance with the Contractor's quality control program,
- The completed bridge structure conforms to the contract requirements.

The Ministry Representatives shall at their own discretion conduct audit testing to verify the Contractor's or Supplier's documented test results.

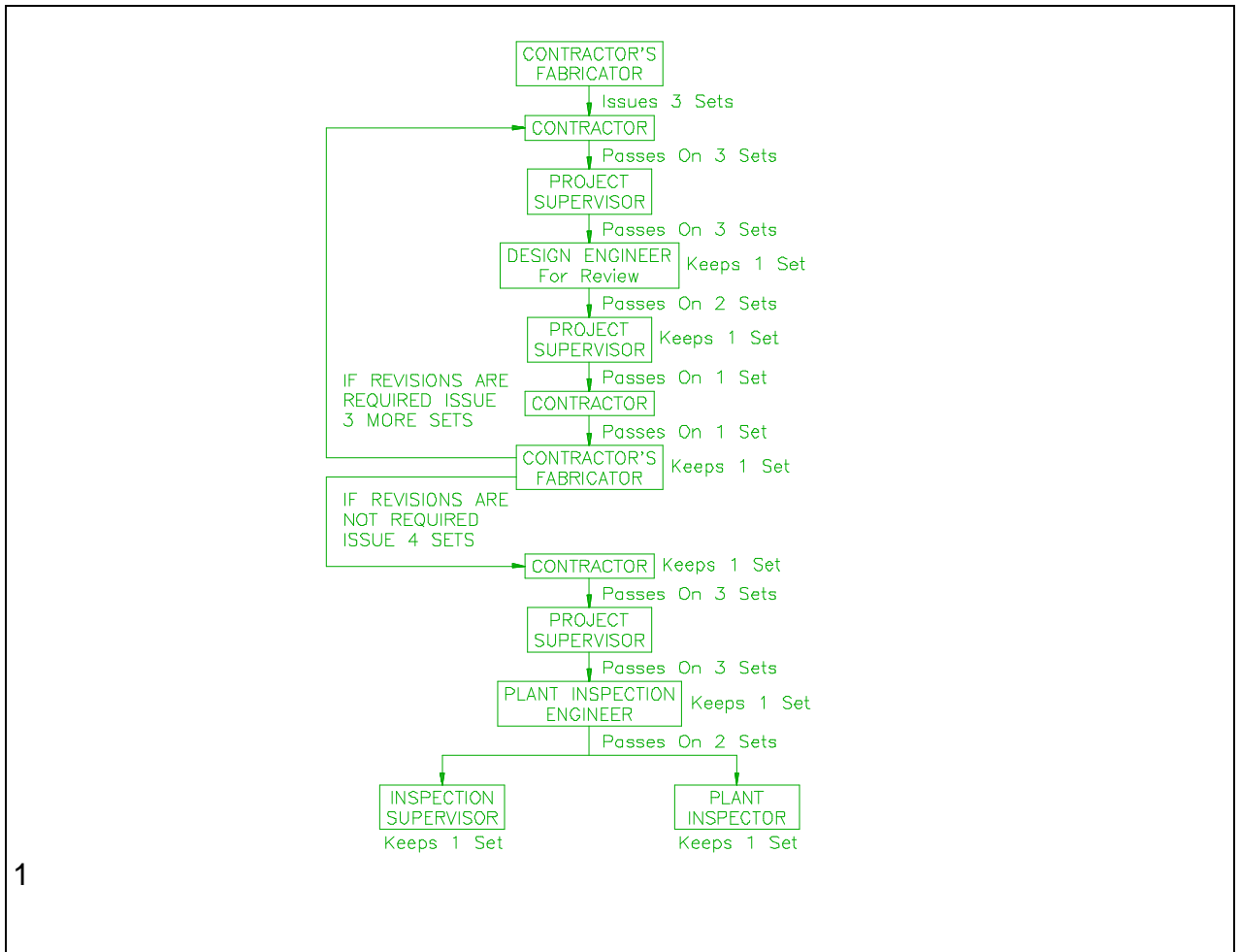
1.14 Alternative Details

The Project Supervisor shall submit in writing to the Design Engineer for approval any proposed variations in the details shown on the Drawings with the reason for the variation and any cost saving or extra cost. The written approval shall be obtained from the Design Engineer prior to constructing any variations to the Drawings.

The Ministry may require the submission of drawings prepared and sealed by a professional engineer registered with APEGBC for alternative details proposed by the Contractor.

1.15 Review of Shop Drawings

The Project Supervisor shall receive three sets of shop drawings from the Contractor. The Project Supervisor shall forward three sets to the Design Engineer, who will review the drawings for general compliance with the contract requirements. If no exceptions are taken to the drawings, the Design Engineer shall return two sets to the Project Supervisor, who shall return one set of the reviewed drawings to the Contractor and request for an additional three sets of the reviewed drawings. The Project Supervisor shall subsequently forward three sets of the reviewed drawings to the Plant Inspection and Installation Engineer.



RECORD KEEPING AND DOCUMENTATION

2.01 General

It is important to record an activity or conversation in writing and not leave these events to memory. It is extremely difficult to recall events that have occurred five or six years in the past. If an activity or event is not recorded in writing and there is a conflict in those positions, then the arbitrator or judge is left in a difficult position of determining which witness is more credible.

Good record keeping is based on a fair and unbiased recording of actual facts and not speculation or denigration of personalities. Written factual records of any event will always be preferred over oral recollections or reconstruction of the event.

If a claim or dispute appears to arise this should be recorded with the other parties. Relevant photographs of change in work and circumstances forming the basis of a claim often lead to a quick resolution of the dispute.

Supplemental Agreement forms (H.177) shall be used mostly for instructions to the Contractor.

2.02 Daily Records

The Project Supervisor shall maintain documentation of the following items as applicable to the Project on a daily basis:

- a) Daily Orders for Extra Work (Form H.358).
- b) Telephone log.
- c) Concrete Log detailing the material parameters of the concrete, the location of the concrete within the structure.
- d) Daily material placement log for roadwork materials showing material type and location.
- e) Project Diary (Form H.299).
- f) Documentation of contentious items (Form H.128).
- g) Document and transmit design change requests to the Project Manager.
- h) Pile driving records for each pile in the structured showing hammer type, energy rating, blow count and depth (Form H.53).

2.03 Weekly Bridge Construction Reports

The weekly report (Form H.57) shall be submitted to the Project Manager/Regional Bridge Engineer and copies to the Director of Bridge Engineering, Manager, Contractor Prequalification and District Highways Manager immediately at the end of each week. Comments on the safety aspects of the Contractor's performance shall be included in the reports.

2.04 Monthly Progress Estimates and Reports

Monthly Progress Estimates (Form H.38) and Provisional Sum documentation (Form H.358) and Extra Work Summary shall be prepared by the Project Supervisor as directed in the Contract Administration Manual and submitted to the Project Manager for spending authority. The quantities entered under the heading "This Estimate" shall be agreeable to the Contractor and the Project Supervisor in accordance with the Quantities and Payment clauses in the Special Provisions (Schedule 3). The estimated quantities, once agreed upon, shall not be altered.

The Monthly Progress Estimates and final Progress Estimate must be completed and in the hands of the appropriate spending authority within seven days of the month's end. The appropriate spending authority is usually the Project Manager.

When differences exceeding 10% are anticipated between the estimated quantities and the final pay quantities, the Project Supervisor shall immediately submit an explanation on the discrepancies to the Project Manager as they become apparent. The Project Manager shall be advised on cash flows on larger projects and documentation for justification payment of additional quantities shall be maintained.

SURVEYING AND LAYOUT OF STRUCTURES

3.01 General

The Project Supervisor shall verify through audit surveys the accuracy of dimensions and elevations as the construction works progresses.

3.02 Initial Site Inspection

The Project Supervisor shall be responsible for the initial site inspection and perform a confirmative survey during the pre-tender period. The Contractor shall assume full responsibility for the setting and layout of the structure (Section 191.04 "Layout of Work", Standard Specifications).

3.03 Dimensional Tolerances

The dimensional tolerances are stated in Section 191.04 and Table 211-M of the Standard Specifications.

The centreline distances of the anchor bolt groups shall be accurate to $\pm 10\text{mm}$. Any greater error may result in the superstructure not fitting and hence requiring a difficult and expensive adjustment during erection.

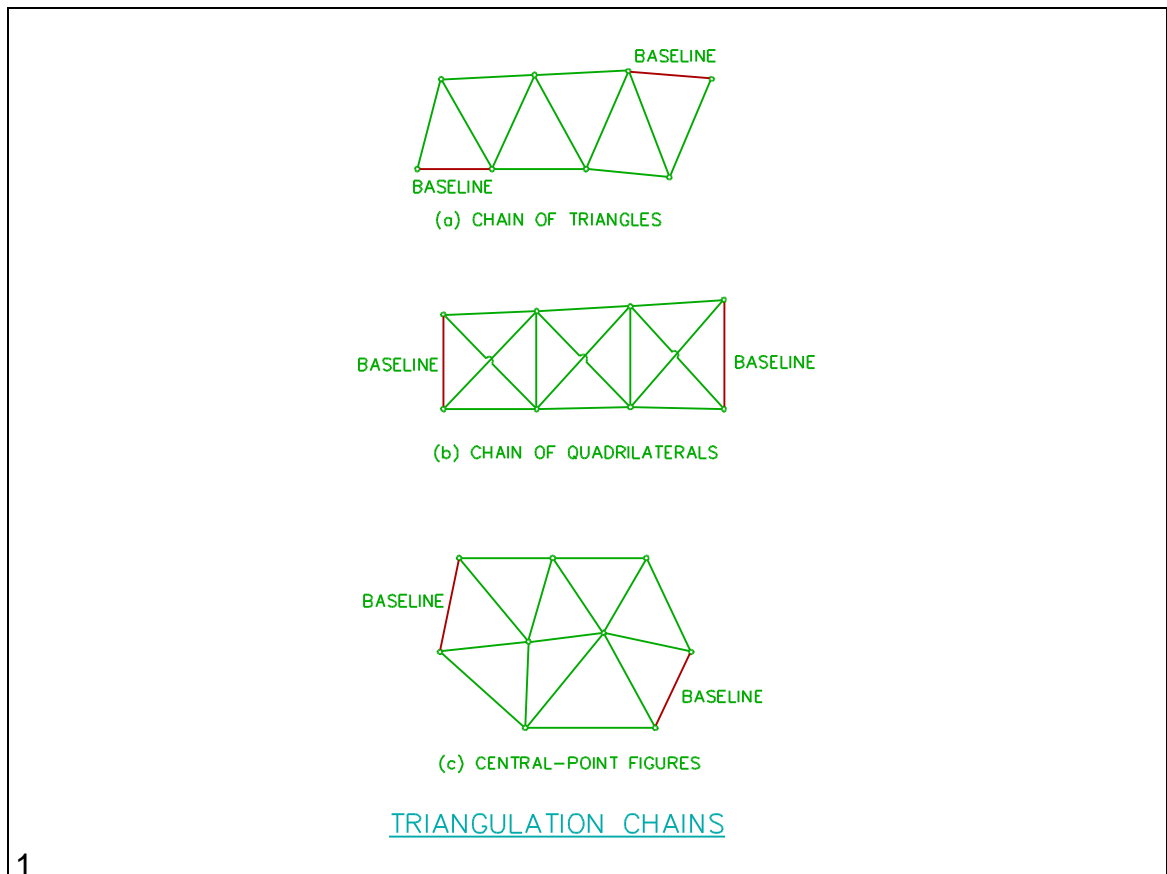
The distances face to face of the ballast walls shall be accurate to $\pm 13\text{mm}$. The elevations for bridge seats shall be accurate within $\pm 5\text{mm}$.

3.04 Triangulation

In triangulation, the points are located at the apexes of triangles, and one base line and all angles are measured. Additional base lines are used when a chain of triangles, centre point figures or quadrilaterals are required. All other sides are computed. Angles used in computation should exceed at least 15° or preferably 30° to avoid rapid change in sines for small angles.

3.05 Trilateration

Trilateration has replaced triangulation for the establishment of control since the development of electronic measuring devices. In trilateration, all distances are measured and angles are computed when needed.



3.06 Equipment

Since the introduction of the first electronic distance measuring instruments (EDMI), numerous improved EDMs with increased efficiency, ease of operation, greater range, and higher precision have been developed. Correction factors can be dialed to eliminate calculations required previously, and various models are suitable for staking and layout of bridge construction projects.

For distances under 100 metres, the theodolite and the EDM have comparable angular accuracies. As distances increase beyond 100 metres, the EDM provides better accuracies.

The use of the "first order" instruments is recommended for tunnels and long bridge structures and where large differences in elevation are encountered. The Alex Fraser Bridge is an example where precise instrumentation was used for the placing of the forms for the concrete towers. A high degree of accuracy is required for the layout of long span bridge structures.

The establishment of horizontal control networks for bridges is performed by a combination of triangulation and trilateration. Angles are measured by the directional method with a theodolite whose least count is 1" of arc. The directions are measured in

six sets and their means shall leave the maximum standard deviation of 2" of arc. The length of lines are determined by EDM.

The triangulation points shall be carefully marked by heavy hubs driven one metre into the ground or more if there is a danger of heaving by frost.

The instruments shall essentially include:

- (a) A theodolite for measuring horizontal and vertical angles.
- (b) An EDM for measuring distances.
- (c) Level c/w rods..

Instruments fall into two categories, viz., "first order" and "second order" based on the standard deviations of individual products and models.

	EDM	THEODOLITE
First Order	$\pm(3 \text{ mm} + 3 \text{ ppm})$	$\pm 1 \text{ second or } <$
Second Order	$\pm(5 \text{ mm} + 5 \text{ ppm})$	$\pm 3 \text{ seconds or } >$

The other accessories are stakes, pencils, survey books, markers, plumb bobs, hammer, handsaw, axes, tapes, shovels and a 2 kg sledge hammer.

3.07 Procedure

The procedure adopted to lay out any given bridge is site specific. The site shall be carefully studied and the method adopted shall give the greatest accuracy of measurement, and the best chance to check important measurements by alternative methods. All principle marks shall be located away from the construction operations and well referenced to avoid being disturbed during construction.

Preference shall be given to the direct measurement of distances, although inaccessible piers can be very accurately located by triangulation if a good base can be laid out and favourable intersection angles obtained.

In spite of the relatively large allowable error in the location of piers, great care shall be taken to locate them as accurately as possible since there is always the possibility that lack of accuracy in the formwork, or movement of the formwork will throw the pier further out of position.

The important dimensions, such as centre to centre of anchor bolts, and face to face of ballast walls shall be checked on the formwork immediately before and during the placement of concrete. Regardless of the method used previously to lay out the structure, these important dimensions shall be checked by direct measurement whenever possible. For this purpose, it is advisable to run two lines coinciding with the centre lines of each outer stringer or truss, and to measure anchor bolts centres, etc. on each line. This not only measures the important dimensions directly, but also provides a check on the orientation of the piers and abutments.

It is a good idea to scribe a line on the surface of the concrete into which a tack can be driven to mark the centres of anchor bolt groups, centres of piers, abutments, etc. The points are useful in checking the work, after it is built, and are useful in setting the superstructure when erection commences.

The main substructure dimensions shall always be carefully checked after construction and any discrepancies from the dimensions called for on the plans shall be reported immediately to the Project Manager and Manager of Bridge Construction. If discrepancies are reported promptly, it is usually possible to make the necessary alternations in the superstructure before it is shipped to the site. Site modifications are difficult and expensive.

All distances shall be measured several times and the true distance is then taken as the average of all measurements taken. Every opportunity shall be taken to check the work, and an entirely independent check by another person is valuable.

3.08 Horizontal and Vertical Alignment

The Project Supervisor shall refer to the Ministry's "Highway Engineering Design Manual" for information on the computations on the horizontal and vertical geometry of the structure.

3.09 Setting Out Spirals

For most practical purposes, the spiral behaves as a cubic parabola and in the field the deflection angles of points within the spiral from the TS or ST are calculated and located for specific chord lengths.

$$\theta_s = 90L_s/(\pi R) \quad \text{where} \quad \begin{array}{l} \theta_s = \text{total spiral angle in degrees} \\ L_s = \text{length of spiral in metres} \\ R = \text{radius of circular curve in metres} \end{array}$$

The spiral deflection $\theta_s = 1/3(\theta_s) - c$ where the correction factor $c = 0.0031(\theta_s)^3$ in seconds and may be neglected for $\theta_s < 20^\circ$

The deflections for spiral chord or subchords vary uniformly with the square of the distance and the forward deflections for the chord.

$$\theta_{sl} = (l/L_s)^3 \theta_s \quad \text{where } l \text{ is the length of the chord}$$

Example (Setting by forward deflections):

Design Speed 100 kph
Radius R = 1500 m
Length of spiral $L_s = 50$ m

TS 197+89.274
SC 198+39.274
CS 202+38.256
ST 202+88.256

Angle of spiral $\theta_s = 90L_s/(\pi R)$
 $= 90 \times 50 / 1500 \pi$
 $= 0.95493^\circ$ or $0^\circ 57' 18''$

Deflection $\theta_s = 1/3(\theta) - c$
 $= 0^\circ 57' 18'' / 3 - 0$
 $= 0^\circ 19' 06''$

First Deflection

Distance from TS (197+89.274) to the first even station (198+00.000) is 10.726m

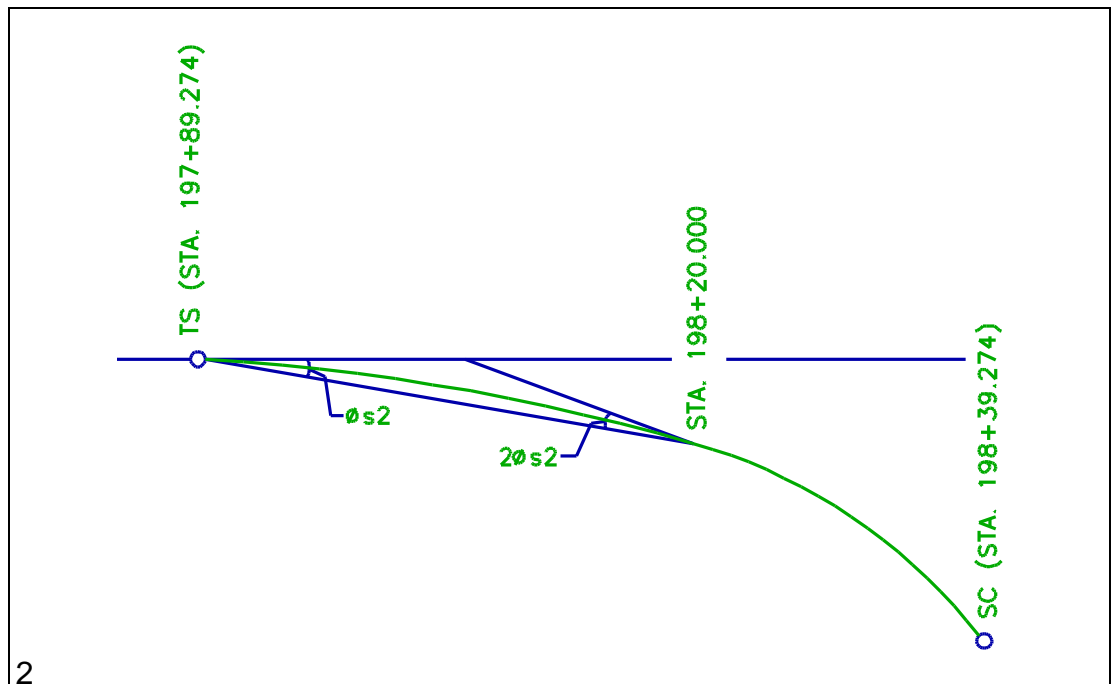
Deflection $\theta_{s1} = (10.726/50)^2 00^\circ 19' 06''$
 $= 00^\circ 00' 53''$

Second Deflection

Distance from TS to Sta 198+20.000 is 30.726m

Deflection $\theta_{s2} = (30.726/50)^2 00^\circ 19' 06''$
 $= 00^\circ 07' 13''$

The remaining deflections are calculated in a similar manner to the SC.



PILES

4.01 Reporting

The Project Supervisor shall keep accurate records of all piles driven on the "Pile Driving Records Form H.53M". Completed forms containing accurate and complete information shall be forwarded to the Geotechnical Engineer and Manager of Bridge Construction. Typical records shall be for each pier and abutment shall be shown on the "As Built" drawings.

As many columns as necessary shall be used for each pile and if one column per pile is sufficient, the remaining columns shall be used for the additional piles. The blow counts for the last 300 mm of each metre shall be recorded and the value of "N" shall be for 300 mm. For very long piles with soft driving at the start, the blow counts shall be taken at 2 metre intervals until the blow count numbers become significant or until the anticipated pile tip elevation is reached. The actual pile tip elevations shall be recorded on the "As Built" drawings.

4.02 Driving Details

The details and methods of driving the piles are included in Schedule 3 (Special Provisions). Details on treated and untreated timber piles are given in Section 214 of the Standard Specifications.

When adjacent piles are being driven, care shall be taken to monitor any heave of piles already in position. The Project Supervisor shall measure the elevation of each pile after completion of driving and again after all piles have been driven at a specific pier or abutment location. Piles that heave shall be re-driven.

A week's notice of the start of the pile driving operation shall be given to the Geotechnical Engineer to arrange for the "Pile Driving Analyzer". When the pile driving operations commence, the Project Supervisor shall immediately fax or phone in the initial results to the Geotechnical Engineer. A record of the elevation of the "soil plug" at the end of the pile driving operation shall be kept for "open ended" piles.

On completion of driving piles for each foundation and before concreting commences, the relative positions of the driven piles shall be discussed with the Senior Bridge Construction Engineer if these are out of specified tolerances. This discussion shall be followed up by the submission of a sketch and complete pile driving records.

Ministry of Transportation and Highways

SHEET NO. _____

BRIDGE CONSTRUCTION
PILE DRIVING RECORD

BRIDGE WET RIVER MASS OF 1500 FOUNDATION PIER #2
 MAKE OF _____
 HAMMER (kg)

PROJECT NO. 07804 ENERGY (kJ/m) 35 DATE AS NOTED FILE NO 0850

PILE NO 1			PILE NO 2			PILE NO 3		
M	N	REMARKS	M	N	REMARKS	M	N	REMARKS
1	6	92/06/30	1	7	92/06/30	1	7	92/06/30
2	6	Start 9:00 am	2	10	Start 10:30 am	2	5	Start 1:15 pm
3	6		3	10		3	4	
4	8		4	10		4	6	
5	8		5	11		5	6	
6	10		6	13		6	10	
7	10		7	12		7	14	
8	9		8	15		8	18	
9	12		9	15		9	20	
10	16		10	20		10	23	
11	15		11	22		11	22	
12	20		12	30		12	30	
13	25		13	33		13	40	
14	32	Stop at 10:15 am	14	40	Stop at 11:40 am	14	42	
15	40	Tip elev. 471.6	15	45	Tip elev. 471.2	15	41	Stop at 2:30 pm
16			16			16	45	Tip elev. 470.3
17			17			17		
18			18			18		
19			19			19		
20			20			20		
21			21			21		
22			22			22		
23			23			23		
24			24			24		
25			25			25		
26			26			26		
27			27			27		
28			28			28		
29			29			29		
30			30			30		
31			31			31		
32			32			32		
33			33			33		
34			34			34		
35			35			35		
36			36			36		
37			37			37		
38			38			38		
39			39			39		
40			40			40		
41			41			41		
42			42			42		
43			43			43		
44			44			44		
45			45			45		
46			46			46		
47			47			47		
48			48			48		
49			49			49		
50			50			50		

General Remarks: *Blows taken for last 300mm of each metre*
 Tip Elevation AS NOTED Inspector: _____
 Project Supervisor: _____

(Form H.53N-93)

1

4.03 Splices

Piling shall be spliced, if necessary, in accordance with details shown on the contract drawings and shall be aligned so that the finished piles are straight from end to end. Pile tips and/or end plates shall be installed as shown on the contract drawings.

Welding shall be undertaken by a company approved by the CWB and to the requirements of CSA Standard W47.1, Division 3 or better. All welding shall conform in quality and workmanship to the latest CSA W59. Minimum preheat and interpass temperature shall be in accordance with CSA W59.

4.04 Cofferdams

Foundations and pilecaps are constructed within cofferdams only when details are indicated on the contract drawings. Cofferdams are normally constructed with sheet piles.

4.05 Hammers

The manufacturer's specifications are required to determine the efficiency of the mechanical hammers. The most common types of hammers are diesel hammers, drop hammers and vibratory hammers. The use of fixed leads is recommended.

The energy of a diesel hammer delivered on impact is a combination of the free-fall of the ram and the explosive reaction of the air-fuel mixture compressed by the falling ram and ignited on impact. Diesel hammers are most efficient during hard driving but during easy driving may not produce a regular driving (sporadic ignition). Diesel powered hammers increase in energy as the resistance to driving increases. A reduction in the rate of blows accompanies this increase in efficiency because the stroke increases.

The drop hammers use various masses of ram that have a comparatively low velocity at impact as a result of a simple drop. Drop hammers are versatile and the energy can be increased by increasing the drop height. The drop shall be limited to a maximum of 2.5 metres regardless of the hammer size. Large energy losses in drop hammers through excessive friction can be caused by misalignment of hammer leads with the piles. Consequently significant energy losses can be expected when driving battered piles.

Vibratory drivers produce pile penetration by inducing either resonant frequency (less than 50 Hz) or high frequency (more than 100 Hz) longitudinal vibrations in the pile. They have the advantage of fast penetration and limited noise and are usually most efficient in granular soils. The disadvantages are a limited penetration capacity under hard driving conditions and the limited experience in correlating driving energy with pile resistance.

Vibratory hammers are not recommended for foundation piles except for point bearing piles. Vibratory hammers are most efficient in the installation of sheet piles and piles bearing on rock.

Bearing piles shall be proof driven.

4.06 Hammer Accessories

The use of proper hammer accessories is extremely important to hammer performance. A cap block or hammer cushion is usually positioned between the hammer ram and the drive head (hammer base) to prevent pile or hammer damage during driving.

Hammer cushions ideally transmit the hammer energy to the pile without significant losses. Synthetic cushions made of such materials as micarta and aluminium are significantly more effective energy transmitters and more durable than conventional hardwood and plywood cushion materials.

Pile cushions are often positioned between the drive head and the pile butt of precast-concrete piles to alleviate spalling and cracking due to excessive driving stresses. Pile cushions shall also be constructed to minimize excessive driving energy losses.

The composition and amount of the cushion material is essential in evaluating pile driving data and shall be included in the pile driving record.

4.07 Follower

A follower is used to effectively protect and guide the pile butt below the surface or through water. The follower shall be sufficiently rigid for transmitting the driving energy efficiently and withstand the bending and buckling stresses during the pile driving operation.

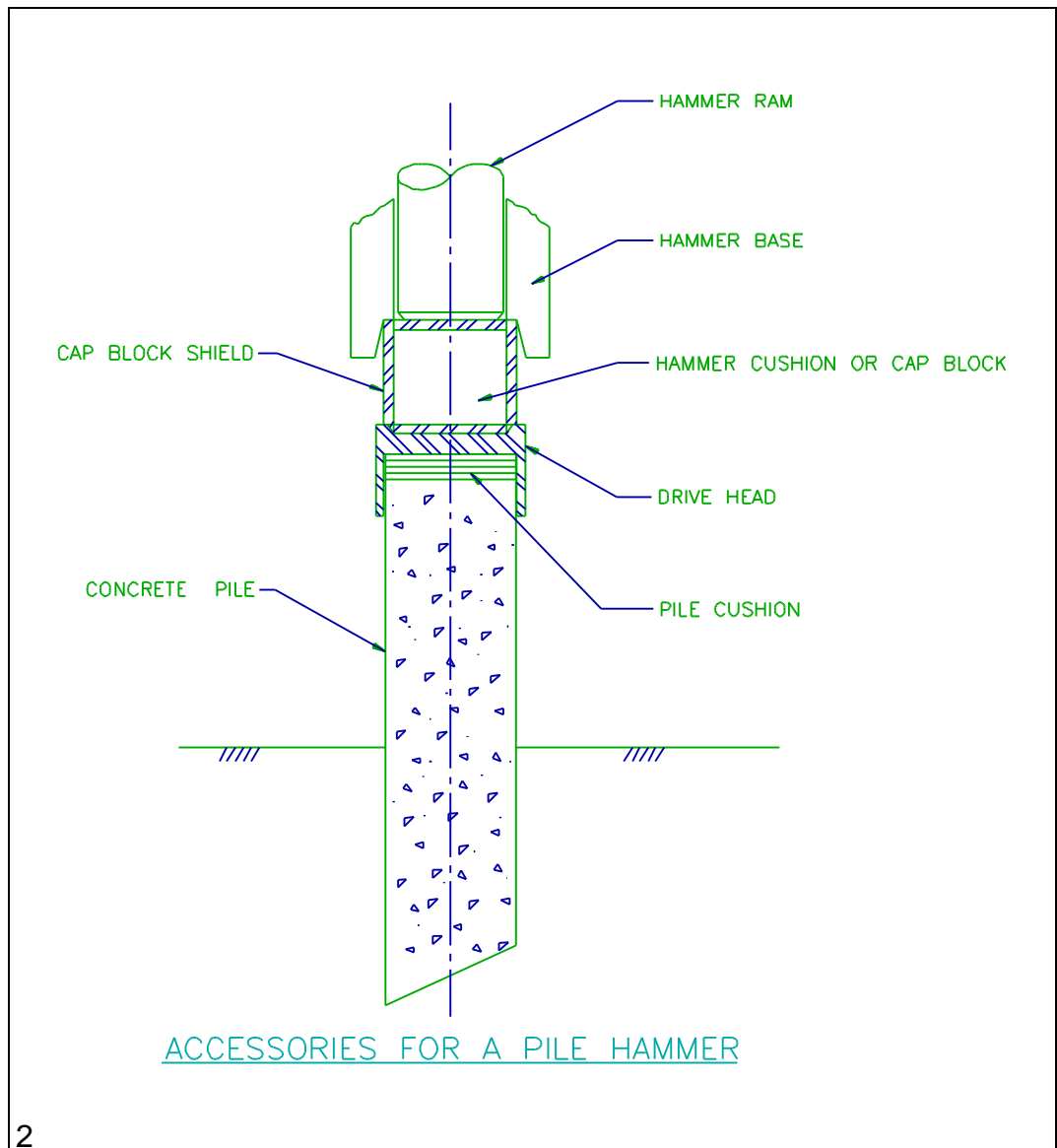
4.08 Mandrel

A mandrel is used to drive steel pipe piles and when inserted into the pile, the mandrel transmits the energy to the base of the pile. This enables the pipe pile to follow the mandrel down without being subject to direct driving stresses.

4.09 Churn Drilling

Churn drilling is accomplished by alternatively raising and lowering a heavy bit which is attached to a crane by a cable. Water in the piling is maintained at a level equal to the surrounding water. The water in the piling forms a slurry with the material ground up by the bit. When the carrying capacity of the slurry is reached, the drill bit is withdrawn and the slurry is removed by a bailer. The pile is installed open ended by a sequence of driving on the head of the pile, alternating if necessary with breaking up obstructions within and ahead of the pile.

The simplicity of equipment and operation, the use of cables instead of drill rods and the requirement of a small amount of water are the main advantages. Churn drilling can be used in most soils and rock and is superior to other techniques in penetrating coarse gravel deposits. However, the method is relatively slow in clay and sticky shale and useless in fine and loose sands.



4.10 Bailer

The bailer is a container used for removing the slurry containing the material ground up by the churn drill and is operated by a separate winch and light cable. Essentially it contains a dart valve or disk valve at the base.

4.11 Template

For piling in water covered areas, it is the normal practice to construct a platform with guides, known as template, for the proposed location of piles to be driven. The piling rigs operate from an adjacent raft or barge.

4.12 Pile Driving Analyzer (PDA)

While the pile installation is in progress, the Geotechnical Engineer may use the PDA to monitor selected piles.

The PDA monitors the stress wave generated by the impact of a hammer blow on the pile utilizing the wave equation principle by means of transducers attached to the pile. The electronic impulses from the transducers are analyzed in the PDA and the results are displayed and printed.

The Pile Driving Analyzer provides the following basic information:

- a) ultimate pile bearing capacity
- b) energy entering the hammer
- c) integrity of the pile.

MATERIALS AND BRIDGE COMPONENTS

5.01 General

The Project Supervisor shall perform the following functions during the inspection of materials, installation of components and erection of girders.

5.01.1 Pile Installation

- Check equipment - hammer, lead and crane.
- Check operators for welding splices, weld procedures and welding certification.
- Verify mill certificates for material compliance. .
- Audit pile driving records.
- Ensure safety by installation of temporary pile caps after driving large diameter steel pipe piles.
- Prepare "As Built" drawing for "Typical Pile Driving Record".

5.01.2 Formwork

- Compute detailed quantities for payment.
- Ensure compliance with engineered formwork drawings provided by Contractor.
- Tabulate final quantities for formwork on marked up "As Built" drawings.

5.01.3 Reinforcing Bars

- Check mill certificates.
- Submit samples for testing.
- Verify epoxy coated bars are clearly labelled with the name of the manufacturer, primer and coating system used and date of production.
- Review test certificates on performance of coatings.
- Check minimum coating thickness of 180mm with magnetic or pencil type pull-off gauges (see ASTM D-3963M, Section 7).
- Review special provisions and audit handling and on-site storage procedures for epoxy coated bars.
- Review order lists and bending diagrams.
- Check splice locations and lengths.
- Perform visual check for grades of bars.
- Tabulate final quantities in kilograms for uncoated and coated reinforcing steel on marked up "As Built" drawings.

5.01.4. Concrete

- Obtain certification from Contractor that aggregates are not reactive.

- Review mix designs provided by Contractor which shall be prepared in accordance with CSA Standards CAN3-A23.1-M.
- Ensure that Contractor follows the quality control tests for slump, air content, temperature and density, records atmospheric temperature, makes test cylinders and delivers to designated test agency for concrete mix proportioned by the Contractor.
- Sample and test Ministry designed concrete for deck, deck diaphragms, parapets, medians and approach slabs.
- Ensure calibration of batch plant equipment.
- Ensure conformance to the requirements for "Hot Weather Concreting" in Standard Specifications, Section 211.17.
- Tabulate final quantities for concrete in the marked up "As-Built" drawings.
- Prepare "Concrete Deck Data & As Built Profile" drawing.

5.01.5 Bearings

- Check for imprint of mark number, date of manufacture and name of manufacturer on face of bearings.
- Ensure elastomeric bearings have been tested in accordance with the specifications.
- Verify the required 5 mm cover of elastomer for top and bottom steel reinforcing plates.
- Check for cracks in the elastomer and for irregular or excessive bulging or splitting under vertical loads.
- Metal Bearings - Check for any breakdown of the paintwork protective system and for
- deformation of the metal plates.

5.01.6 Girders

- Ensure that erection (and transportation) drawings and procedures have been prepared and sealed by a professional engineer registered with the Association of Professional Engineers and Geoscientists of British Columbia.
- Ensure that erection drawings and procedures have been received by the Plant Inspection and Installation Engineer.
- Ensure log books are maintained in accordance with WCB requirement, Section 56 "Cranes, Derricks and Miscellaneous Hoisting Equipment".

5.01.7 Post-Tensioning

- Review procedures for jacking sequence and testing of grout cubes, and list of equipment submitted by Contractor at least three weeks before post-tensioning.
- Cored ducts with concrete walls shall be flushed with clean water prior to grout injection.
- Ducts for external tendons shall be flushed with clean water under pressure to check for leakage and blockage followed by oil-free compressed air prior to grout injection.
- Metal sheaths for internal ducts shall be flushed to clean out foreign materials or oil-free compressed air shall be used to check for blockages.

- Ensure ducts remain open during grouting of shear keys. (e.g. by installing plastic pipe through duct as girders are erected.)

5.01.8 Granular Backfill

- Ensure construction and compaction in successive horizontal layers not exceeding 150 mm in loose thickness in accordance with Standard Specifications, Section 201.14.
- Review test results on compaction of backfill.

CONCRETE DECKS

6.01 Basic Considerations

"Smooth riding" concrete bridge decks can be constructed and the fundamental principles which apply in the construction of "smooth riding" pavement on grade also apply to the pavement on structures. The Project Supervisor shall also refer to Section 237 - "Bridge Decks" in the Standard Specifications.

These fundamentals can be briefly stated as follows:

1. Accuracy in the setting forms and securely supported rails.
2. Properly proportioned mix and consistency in concrete.
3. Proper handling and placing of the concrete mix.
4. Uniform "strike-off" or screeding.
5. Straight edging by experienced pavement finishers.
6. Uniform texturing.
7. Proper finishing at gutter areas for drainage.
8. Proper curing.

Understanding and co-operation on the part of the Designer, Project Supervisor and Contractor are essential to a satisfactory job. The starting point is an accurate structural design and adequate specifications with respect to materials, concrete mix and methods for handling, placing and finishing of the concrete. Considerable emphasis shall be placed on the necessity for sufficient and adequate equipment and finishers experienced in producing bridge decks in accordance with the specifications.

The Project Supervisor, Bridge Deck Supervisor and the Contractor shall meet at least six weeks prior to the construction of the deck and determine:

1. The type and adjustment of screed supports or rails.
2. Equipment to be used.
3. Source of aggregates.
4. Admixtures to be used.
5. Location of batching plant.
6. Procedure for placing, finishing and curing concrete.
7. The required number and qualification of workpersons.

6.02 Design Considerations

The Designer shall incorporate features which facilitate the deck construction and thus contribute to a better riding surface.

Whenever possible, the screed rail shall be located over a stringer or beam. The end dams shall be adjustable to the final elevation in the field. The haunch shall vary in depth between the top of the beam and the underside of the slab to the deck to ensure design slab thickness is achieved. The plans shall show the loading sequence and the calculated deflections due to the dead load of the slab. Longitudinal joints shall be considered on multi-lane decks and shall be aligned with the lane edge of the roadway (i.e. joint shall not be located in wheel path).

6.03 Screed Rails

Screed rails shall be set to a true and smooth grade since they determine the longitudinal surface of the concrete. The cambers and deflections shall be carefully calculated before setting the screed rails.

After erection of the structural members, profiles shall be run on each beam. This shall be done when both the upper and lower flanges have the same temperature. Particularly with steel, great variations occur in deep sections when the upper flange is heated by the sun while the lower flange is in the shadow and is further cooled by its proximity to the water.

The elevation readings taken while the structural members are in "thermal imbalance" will produce accurate results only if they are applied under the same "thermal imbalance" conditions. However, the values obtained from a "thermally neutral" member may be reapplied to that member when thermally unbalanced by making a measured adjustment at the time of application.

The procedure is as follows:

A. Computations

1. The top elevations of the stringer are taken at the screed setting stations during a thermally neutral condition (overcast). Mark the "shot" locations.
2. Screed settings and haunch heights are calculated by Bridge Engineering Branch or Design Consultant. A simple form has been devised to facilitate the transmission of information. The attached plan sketch shows the locations of the shots and these sheets are forwarded to the Project Supervisor in duplicate with the deck drawings by the Designer. The columns are self explanatory and should eliminate misunderstandings relative to location and orientation.
3. A set of forms containing the screed setting and haunch heights are sent back to the Designer, who will determine the final design grade, screed setting and haunch heights.
4. Forms are installed relative to the calculated haunch heights and therefore relative to the stringer tops and screed rails. Screed rails are parallel to set deck forms (theoretically).

B. Setting Screeds (any thermal condition)

1. Calculate the design finish grade elevations for each screed rail adjustment point, corrected for dead load deflection.
2. Adjust for the present thermal condition by rechecking the stringer elevations against the original values taken during the thermally neutral conditions. Add or subtract the difference to the screed elevation at each adjustment point.

3. Proceed to set the elevation of each screed rail adjustment point with the deck machine on the rails. The deck machine must be loaded with a weight equivalent to the weight of the concrete deck supported by the overhang form bracket and weight of deck machine operator to take any deflection of the rail supports into account.
4. Set the final height of the deck machine (using the leg adjustments) to give the design deck thickness.
5. Run the loaded machine back across the set screed rails checking the rebar cover and deck thickness.
6. Make adjustments as necessary to form hangers to ensure minimum rebar cover is maintained.

The screed rail shall be checked by eye to give a smooth surface free of minor irregularities.

Finishing machines shall be operated on temporary rails supported on structural members only if these are outside the inner curb faces. Alternatively the curb formwork shall be constructed to accommodate the additional weight of the machine without causing deflection. Screed rail supports shall have positive lateral support and shall have a spacing not exceeding 1.2 metres. Screeds shall be set for the entire length of the bridge prior to the casting of concrete. Screed rail supports also serve as carriers for work bridges.

The final check for grade shall be made with the rails carrying the machine.

Each bulkhead and expansion joint block out shall be checked for grade with the "set-up" machine, prior to the casting of the adjacent sections.

C. Transition Lengths and Adjustments at Hinge

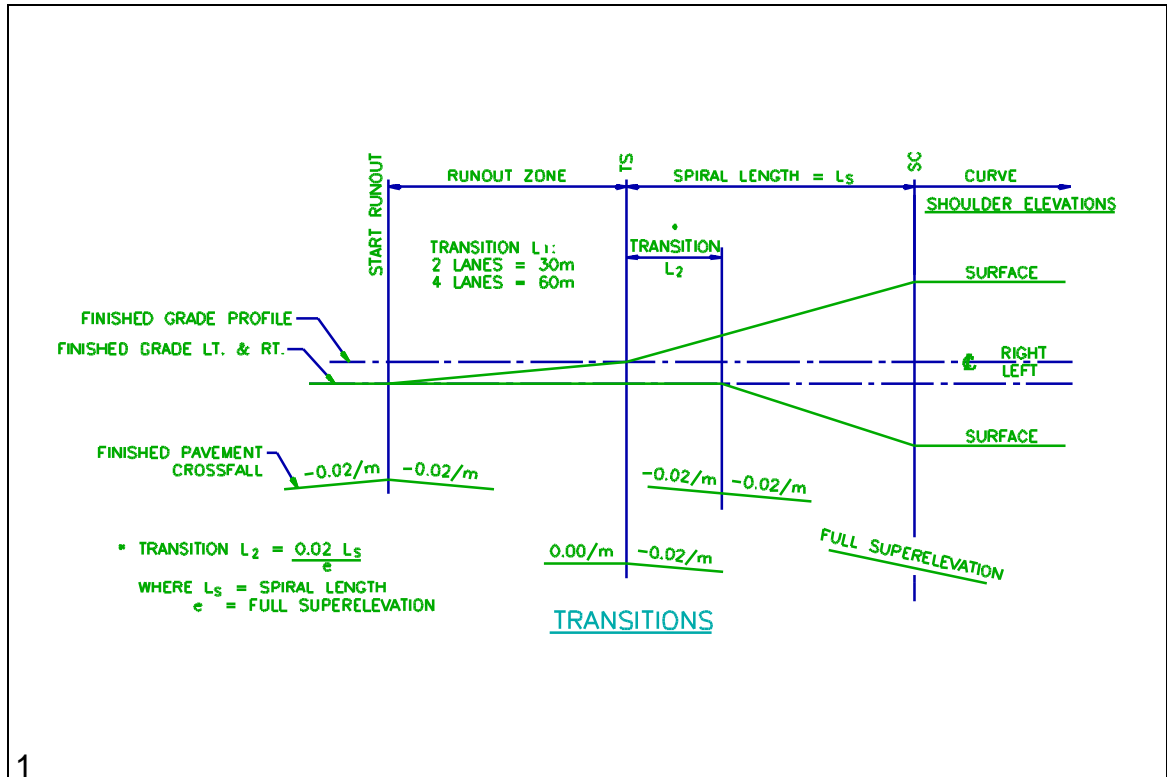
Transitions are required to provide a gradual change in curvature from a straight to a circular path; and provide some degree of driver comfort during change in the crossfall of the roadway. On the tangent and towards the T.S. (tangent to spiral) or S.T., a rate of change of 1:400 is recommended from a 2% crowned section to a level section; and a rate of change of 1:200 within the spiral from a level to a 2% superelevated section. For uniformity, the Highway Engineering Branch has recommended a transition length L_1 of 30 metres and 60 metres for two and four lanes respectively to the T.S.; and a transition length

$$L_2 = 0.02L_s/e$$

where L_s = spiral length
 e = full superelevation

within the spiral from a level to a 2% superelevated section.

Transitions shall be used on bridges located on horizontal curves to effect gradual changes from crowned or level sections to superelevated sections. In bridge decks where crown profile alters to accommodate the superelevation, special attention shall be required for the finishing machine "set-ups."



It is essential for the hinge in the finishing machine frame to be positioned on the centreline of the roadway. The adjustment for superelevation can be then made solely with this hinge. The procedure is as follows:

1. Set screed rails relative to the finished concrete grade at the curbs.
2. Reduce the crown in the frame of the machine to zero and set the carriage tracks parallel to the longitudinal axis of the main frame members.
3. Stretch the mason's lines from end to end of the machine at the front and back main member and over the carriage track (See Fig. 1). These lines shall be equidistant above the screed rails and also the ends of the carriage tracks.
4. Measure the vertical distance "D" from the lines to the top of the carriage tracks over the screed rails. The ends of the carriage tracks shall remain a constant distance from the screed rails and hence the finished concrete surface.
5. Subtract the design crown, "C", from this measured distance and set the top of the carriage track (D-C) = "X" from the string line at the centreline of the roadway. This is done by adjusting the hinge arrangement on the main frame of the machine. The design crown shall now be held by the finishing machine.
6. Lay out the transition L₁ to effect a gradual change from the 2% crowned section to a level section from the outer edge of the deck to the centreline of the deck (see Fig. 2b). Lay out the second transition L₂ from level to the 2% crowned section within the spiral (Fig. 2b).
7. The maximum recommended adjustment at the hinge is 3mm for the computed incremental travelled distances of the finishing machine.

The part of the "rough riding" due to an irregular grade line which is composed of a series of curves shall be eliminated by the foregoing points. However, many "rough riding" pavements result from improper methods of handling, placing and finishing concrete. These operations can produce a rough and uneven pavement if improperly performed; even though it may conform generally to a true grade line.

6.04 Worked Example

Sombrio #2 Bridge No. 1495 (Region 6 - South Island Highway District) is a two lane bridge with the following geometric data:

Design Speed = 70 kph
 $R_o = 190$ metres Left
 $\nabla = 48^\circ 07' 51''$
 $T_c = 84.853$ metres
 Arc = 159.608 metres
 $E_c = 18.087$ metres
 $e = 0.060$
 $L_s = 70$ metres

The maximum spacing of the screed rails is 10.8 metres and the hinge of the finishing machine is located at the centreline of the roadway.

Solution:

Transition length $L_1 = 30$ metres (for two lane bridge)

Transition length $L_2 = 0.02L_s/e$
 $= 0.02 \times 70 / 0.06 = 23.33$ metres

Displacement of location of screed rail from normal crown of 2% to level section

$$C = 0.02 \times 10.8 / 2 = 0.108 \text{ metre}$$

Corresponding adjustment required at location of hinge = $0.108 / 2 = 0.054$ metre

Use 3mm as the maximum crown adjustment at the hinge.

Total number of adjustments required at hinge from 2% crowned section to level section

$$n = 0.054 \times 1000 / 3 = 18$$

For transition length L_1 distance between adjustments = $L_1 / n = 30 / 18 = 1.667$ metres

For transition length L_2 distance between adjustments = $L_2 / n = 23.333 / 18 = 1.296$ metres.

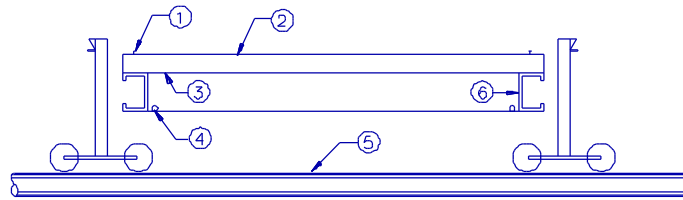
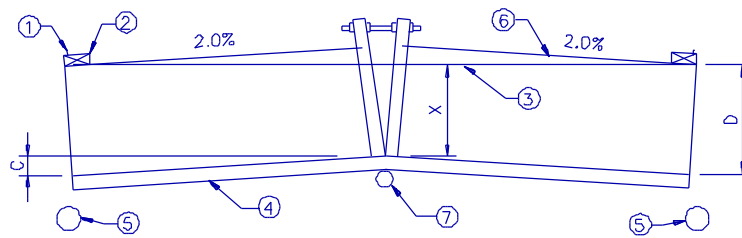
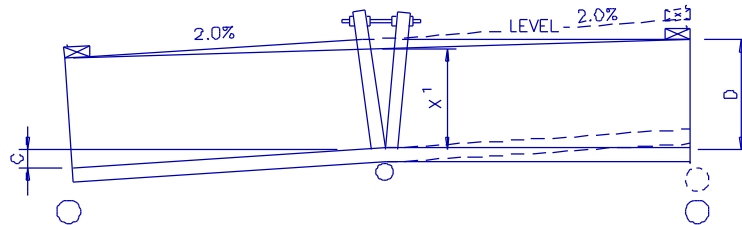


FIGURE 1



NORMAL CROWN
FIGURE 2a



LEVEL (T.S.) AND 2% SUPERELEVATION (IN SPIRAL)
FIGURE 2b

- ① NAIL FOR ANCHORING STRING LINE
- ② 2" x 4" FASTENED TO EACH END OF FINISHING MACHINE
- ③ NYLON STRING—END TO END, EACH SIDE
- ④ CARRIAGE TRACK
- ⑤ SCREED RAIL
- ⑥ FRAME MEMBER
- ⑦ HINGE

NOT TO SCALE

6.05 Concrete Mix

A uniform concrete is a prerequisite for a "smooth riding" pavement. The composition, workability and slump are specified in the Special Provisions (Schedule 3). Water content shall be kept to a minimum and the specified water/cement ratio shall never be exceeded. If the necessary plasticity requires water in excess of that specified, additional cement shall be judiciously added to maintain the specified water/cement ratio.

6.06 Handling and Placing Concrete

The essence of easy to handle concrete is "freshness". Site mixing is preferable and concrete over 45 minutes old, including batching, hauling and unloading time, shall not be used in bridge decks. Concrete shall be placed as near as possible to its final location. Shovels or rakes shall be used for moving the concrete but "vibra-shovelling" shall not be permitted.

The concrete shall be placed on a full width heading in a strip about 0.75 metre wide and a systematic approach shall be used. The concrete shall be placed, raked and levelled with shovels as necessary, vibrated and then finished. If the vibrated concrete has to be "walked in", the footprints shall be re-vibrated. A vibrating pattern shall be established, such as inserting the vibrator vertically on a 0.3 metre grid, holding for a one count, withdrawing on a two count, and then re-inserting. Special attention is required in vibrating the concrete in the vicinity of the interfaces of adjacent concrete strips. These areas shall be thoroughly consolidated to eliminate the development of porous concrete. The Project Supervisor shall insist that only one instructed and trained workperson does the vibrating. The leading edge of the concrete shall be kept straight and the system shall operate simultaneously in three stages, viz., (i) placing, (ii) consolidating, and (iii) finishing.

CAUTION It is NOT advisable to get too far ahead with the placing of the concrete since there is always the possibility of equipment failure or heavy rainfall. A maximum distance of one metre is recommended.

6.07 Screeding Concrete

The finishing machines shall be moved slowly and at uniform increments along the rails which have been accurately set and securely supported. The placing of concrete shall proceed parallel to the finishing machine.

The screeds shall strike off the full width of pavement in one operation. On multi-lane pavements, it may be possible to install a longitudinal construction joint.

NOTE Walking on the concrete is prohibited after the screeding operation since it pushes coarse aggregate aside and leaves a pocket of mortar. Mortar pockets, unless properly filled, wear more rapidly and are more absorptive.

6.08 Finishing Concrete

A minimal amount of hand finishing is required when the concrete is properly designed, mixed, placed and machine screeded. Areas of open surfaces shall be closed with a wood float from a work bridge and immediately textured. A coarse texture is necessary for skid and wear resistance.

The concrete surfaces shall be kept continuously moist by acceptable curing methods and procedures. A second work bridge shall be used to apply wet burlap and polyethylene sheet as soon as the concrete has set sufficiently. The "touch test" shall be used and if the mortar sticks to the fingers, it will not be advisable to place the burlap. If a drying situation exists, the surface shall be kept moist with fogging nozzles. The type of nozzles obtainable at the garden shops are ideally suited but the "fire hose" variety shall not be used.

If voids are observed on the surface during the placement of burlap, the affected locations shall be filled on the following day by brooming sand/cement slurry into the voids.

Simple screeding off the fresh concrete and applying a surface texture is not adequate to finish a pavement expected to have a "smooth riding" surface. It is important to provide an adequate design and specifications, and the Project Supervisor and the Contractor shall review the matters concerning equipment and procedures essential for paving. Careful planning will provide that the requirements are met and the best results will be more fully assured on carrying out of the work.

6.09 Equipment

The tools required for testing of concrete are:

- Slump cone
- Air entrainment meter
- Speedy moisture meter
- Platform scales
- Fortex buckets
- Scoops
- Thermometer
- Cylinder moulds
- Cylinder transportation moulds
- Sling psychrometer

COMPLETION RECORDS

7.01 Opening and Speed Limits of New Structures

The opening of the structure to the travelling public is the responsibility of the Project Manager.

The Project Supervisor shall keep the Project Manager/Regional Bridge Engineer informed on the date when the structure is available to traffic.

7.02 Substantial Completion

A Certificate of Substantial Completion, in accordance with Section 25 of the Construction Agreement, shall be forwarded to the Project Manager.

7.03 Final Inspection at Completion of Contract

The final inspection shall be carried out in accordance with Sections 26 of the Construction Agreement. A report summarizing the inspection, noting any changes or defects shall be submitted to the Project Manager.

The final joint inspection team shall consist of the Project Supervisor, Project Manager, Regional Bridge Engineer, Area Manager Bridges and the Manager of Bridge Construction.

7.04 Completion Records

Within one month of completion of the construction project, two copies of the "Project Record" documentation containing the following information with a table of contents and a narrative summary shall be assembled and submitted to the Project Manager:

- a) Project description.
- b) Summary of project costs.
- c) Contractor's performance (maximum of two paragraphs).
- d) Summary of total payments for the project.
- e) Summaries and copies of Extra Work and Change Orders.
- f) Construction photographs (maximum 20).
- g) A complete log of all concrete placement summarized on a standard "Concrete Inspection Report" (Form H47).
- h) Summary of the material placement for roadworks.
- i) A complete driving record for all piling.

7.04.1 Shop Drawings

The Project Supervisor shall co-ordinate the distribution of shop drawings as described in Section 1.14 of this manual.

The Project Supervisor must ensure that the Plant Inspection and Installation Engineer receives three reviewed copies of all shop drawings to facilitate plant inspection during fabrication, and to forward to the Bridge Engineering Branch files for future microfilming.

7.04.2 As-Built Drawings

At the completion of construction, the Project Supervisor shall submit marked up prints of all contract drawings showing as-built changes; final tabulated quantities for formwork, concrete, uncoated rebars, epoxy coated rebars and structural steelwork; and additional drawings on "Deck Concrete Data and As-Built Profile" and "Typical Pile Driving Record" to the Bridge Construction Engineer, Bridge Engineering Branch.

In the event that no changes have been made during construction and as-built drawings will not be forwarded to the Bridge Engineering Branch, the Project Supervisor shall inform the Bridge Construction Engineer in writing.

As-built drawings shall show in detail any difference between the contract drawings and the actual structure. All differences shall be shown in red on prints of the contract drawings. For example, differences in elevations, dimensions, reinforcing, etc. shall be recorded. In addition, the actual clearance at each expansion joint and the distance between the end of the stringers and the abutment ballast walls shall be recorded along with the atmospheric temperature at the time of measurement.

Each as-built drawing shall be dated and initialed by the Project Supervisor, indicating that a review of the sheet has been made. A copy of the covering letter shall be sent to the Project Manager.

7.04.3 Concrete Deck Data and As Built Profile Drawing

The Deck Concrete Data and As-Built Profile information shall be submitted on a reproducible full size standard drawing 600mm x 800mm (see sample drawing in Appendix) and shall include:

- a) Concrete mix design and adjustments
- b) A sketch of the deck showing the direction and extent of each day's placement of concrete
- c) Concrete data for each load delivered to the site:
 - i) Load number and volume
 - ii) Time of arrival and time when truck was emptied
 - iii) Temperature, slump, % air, and unit weight
 - iv) Identify where each load is placed
 - v) Describe any changed conditions
- d) Concrete cylinder strengths
- e) A table of deck elevations (design, as-built and the difference), at 3 metre intervals, along the centreline of the roadway and 0.3 metre offset from curb lines.

7.04.4 Typical Pile Driving Records Drawing

Pile driving record forms for at least one pile in each abutment and pier shall be placed on a full size standard drawing 600mm x 800mm (see sample drawing in Appendix). Additional record forms shall be included when one pile is not representative of all the piles in a given substructure.